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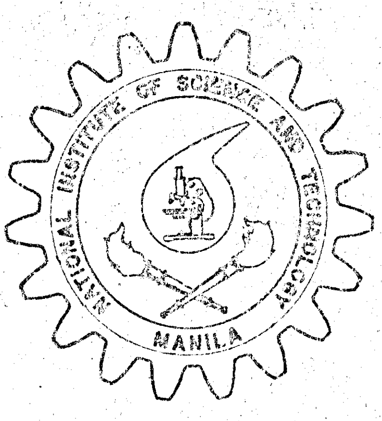
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THE NATURE AND PROPERTIES OF THE EMULSIFIER SYSTEM OF OIL GLOBULES IN COCONUT MILK AND CREAM

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The white opaque liquid expressed from finely comminuted meat of sound ripe coconuts (*cocos nucifera*) is a natural oil-in-water emulsion which is generally called "milk." This liquid is, in fact, a thick cream. If the residue is mixed with the coconut water or with the same volume of tap water, coconut milk is obtained. By gravity separation it forms a top layer, the coconut cream; and a lower layer, the coconut skim milk. Both layers are opaque, but the upper appears denser and thicker.

As long as the oil globules of the cream remain in the liquid state, no amount of churning can produce coconut butter or get rid of the skim milk still present in the cream. But, when the oil globules solidify when the temperature is reduced to a few degrees below 10°C, for a period of about 30 minutes, the coconut cream becomes churnable. By churning, the water content of the cream may be reduced from around 50 to 8.7 per cent and the protein from 5 to 3 per cent.

This characteristic of cold coconut cream has become the basis for the development of a novel process(4) of producing quality-white coconut oil with remarkable keeping quality. Samples of this have been found to keep good for years. We believe that the quality oil produced without the agency of heat possesses a powerful antioxidant which enables it to maintain long shelf

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life. This property of cold coconut cream also furnishes the deproteinized dewatered cream the basis for the isolation of the naturally occurring emulsifier system of coconut milk and cream that remains dissolved in the oil.

Clemente and Villacorta(5) averred that colloidally dispersed proteins absorbed at the oil-water interfaces and sugar dissolved in the aqueous phase play the role of emulsifying agents. They believed that coconut milk, like cow's milk, is essentially an emulsion of oil in water stabilized by proteins and probably by some ions absorbed at oil-water interfaces. De Leon and Soliven(6) subscribed to this idea; but their paper, as well as Clemente's, lacked experimental proofs.

Lava(7) stated that the coconut cream emulsion is stabilized by the presence of minute particles of materials of protein characteristics and that when the emulsion system is adjusted substantially to their isoelectric point, these particles, which surround the oil globules, separate or precipitate, breaking the emulsion and permitting the oil globules to coalesce. He advanced the idea that these fine particles stabilize the emulsion only when in hydrated form and that as soon as dehydration is brought about, the protective property ceases and the emulsion is broken.

Accordingly, he adjusted the pH of the coconut cream emulsion between 3 and 5.6 by adding hydrochloric acid and produced quality water-white coconut oil. This may be a plausible explanation for the discharge of the actual emulsifier in the coconut cream emulsion; but there may be another substance responsible, besides cocoasin, the isoelectric point of which is within a pH of 3 and 5.6 and the mechanics of its discharge is not as what Lava indicated. The present paper deals with this particular substance which prevents the coalescence of the oil globules in coconut milk and cream and affects the saponification value[1] of the oil.

We have in coconut milk and cream a complex oil-in-water emulsion in which the presence of protein in a colloidal state, of dissolved sugars, salts, and other substances in the continuous aqueous phase, produces an ideal solution of oil-in-water in which the noncoalescence of the oil globules is its fundamental nature. The search for the cause of the stability of the natural emulsion of oil in water, like dairy milk, has been done in Europe and America. As early as the turn of the 19th century, it was generally held that the butter globules in milk and cream are surrounded by albuminous matter of milk and cream which in some way condenses on the surface of the butter globules to form, according to Ascherson,(1) the haptogenic membrane, which must be broken before butter can be formed. Clemente and Lava, in the Philippines, explained in the same manner the noncoalescence of coconut oil globules in coconut milk and cream, only their explanation came a century later.

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[1] Birosel and Gonzales, Philip. Jour. Sci. 90 (1961) 465–478.

Babcock(2) rejected Ascherson's explanation and proposed his own of cells filled with butterfat, the constituent of the cell wall of which was not made clear until a few years later(3) when he identified traces of febrin in milk and lacto-febrin as the material of the cell wall.

Babcock's explanation for the noncoalescence of butterfat did not gain as wide an acceptance as Ascherson's theory, which had prevailed for half a century before Babcock came into the scene. But throughout the history of dairy science, students in this field have always held on some kind of membrane to explain the stability of dairy milk and cream. Palmer(8) and his students devoted over three decades to the study of this problem and throughout the period of inquiry they had always held on the membrane idea to describe the special fat emulsifying system supposed to be found in cow's milk. Their efforts culminated in the identification of a protein-phospholipid complex as the natural globule membrane in the special fat-emulsifying system.

We are not certain whether this concept will remain for all time a valid explanation for the stability of dairy milk and cream and the noncoalescence of the butterfat globules to form butter. Our experience does not show either that coconut milk and cream and dairy milk and cream have identical fat emulsifying systems. But we are inclined to believe that coconut milk and cream has a special oil-emulsifying system different to that found by Palmer and his students in dairy milk and cream to explain the noncoalescence of coconut oil globules. This suggests the presence of a fundamental difference between the emulsifying systems of the two types of milk.

EXPERIMENTAL AND DATA

During the Japanese occupation of the Philippines, when the edible-oil factories were not in operation, we produced edible coconut oil by boiling the raw oil with salt solution. We thought it would be simpler and less costly if the same thing

Washing had to be done in successive steps, as each eliminated an amount which lowered the saponification value by one point, more or less.

The mixture was milky white while being washed; upon standing, the immiscible liquid separated. Both parts appeared opaque, but became lighter as the oil approached the saponification value of pure coconut oil. When the oil layer heated after each washing, there was always separated an amount of more or less dark solid material. As heating started, innumerable fine globules dispersed in the oil became apparent, their size diminishing as heating continued; finally the material of the cell walls was left behind as fine, dark, solid particles. When these were filtered, the color of the oil obtained was the same as that of the original. The saponification values after each washing are found in Column 1, Table 1.

TABLE 1.—*Effect of washing on saponification values of different coconut oils.*

Saponification determinations	Saponification values				
	Quality oil taken direct from coconut milk Subtractive processed oil (1)	Quality oil from heated coconut cream Rural oil (2)	Cold pressed dessicated coconut meat oil (3)	Quality oil from tap-water washed cream (4)	Quality oil distilled water washed cream (5)
At the start	251.37	253.37	250.99	250.25	250.95
After 1st washing	250.28	251.70	249.57	250.12	249.27
After 2nd washing	249.50	250.12	248.35	248.79	248.66
After 3rd washing	248.35	248.46	248.10	248.12	248.06
After 4th washing	248.17	248.13	248.01	248.10	----------
After 5th washing	248.01	248.05	----------	248.02	----------

The quality oil obtained by rendering coconut cream in controlled heat was found at the start to give a saponification value of 253.37. It was subjected to a process of elimination with the same procedure as the oil above. The saponification values obtained after each washing are shown in Column 2 of the same table.

The quality oil prepared by cold pressing dessicated coconut meat in the Carver press was also washed multiple of times and the saponification value for dry oil was obtained after each washing. The data are in Column 3 of the same table.

Quality oil prepared from coconut cream by washing with tap water recorded at the start a saponification value of 250.25.

It was also subjected to a process of elimination of the definite substance that affects its saponification value. The saponification value of dry oil was taken after each elimination and included in the table, Column 4.

Quality oil prepared from dewatered coconut cream and washed multiple of times with distilled water gave a saponification value of 250.95 at the start. It was washed with distilled water as above oils and the saponification value of the dry oil was taken after each elimination. Data for this are also included in Column 5 of Table 1.

Coconut cream separated from the aqueous phase of the emulsion by gravity forming cream larger on top and skim milk below. Both layers simulated the opaque appearance of dairy cream and skim milk. The opaqueness was more intense in the cream layer where there were closely packed oil globules, suspended protein particles, and the continuous phase with all the dissolved substances. After an hour of gravity separation, the volume of the aqueous phase in the cream layer remained greater than the volume of the dispersed oil globules, and its protein content was much more than what was present in the skim milk.

Coconut cream becomes churnable when the natural emulsion is cooled to solidify the oil globules. By churning we were able to dewater the cream to the lowest level possible and obtained "cream skim milk" which had greater protein content than the skim milk from which the cream was originally separated. When the solid dewatered cream was washed with cold water, it yielded less protein than the original skim milk. From this we gathered that coconut cream could be washed outright with water to free it from protein and dissolved substances in the continuous phase of the emulsion without change in the emulsion state of the original cream. This process would prove useful in isolating and identifying the natural oil globule membrane which prevents the globules from coalescing and maintains the stability of the emulsion system.

We took 845 cc of cream from 4 nuts and cooled it in the refrigerator to solidify the oil globules and make the emulsion system as churnable as the cream of dairy milk. The temperature of the frozen cream went down to a little above 5°C. Thawing was hastened by warming the cream with warm water. When it was all liquid and the temperature was still below 10°C, it was churned with a wooden paddle. As the system warmed up churning continued until the emulsion system became plastic at first, then lost its plasticity, and granulated afterwards. On further churning the continuous phase oozed out and the granules were pressed to separate the opaque aqueous portion or cream skim milk. The solid portion was kneaded to eliminate all traces of cream skim milk, which contained more proteins than the original skim milk.

The solid dewatered cream was melted and transferred into a 2-liter separatory funnel and washed eight times with distilled water twice its volume. There was separated 455 cc of cream skim milk and 390 cc of dewatered cream, which contained very much less proteins than the original cream. After the washing, a water-in-oil emulsion was obtained, which was a reversal of the original oil-in-water emulsion. When the system was allowed to stand, the heavier water globules settled at the bottom.

The water-in-oil emulsion was separated and congealed for kneading to get rid of extraneous water. Two holes were made on the solid mass to allow the water that settled at the bottom to escape. The mass was then kneaded to remove the remaining extraneous water by absorption on a strip of filter paper. When the solidified emulsion became soft it was cooled and kneading continued. When all extraneous water appeared to have been removed, the solidified emulsion was liquefied by heating or by allowing it to warm up to room temperature. When left standing, the liquefied emulsion released all remaining water globules and made itself ready for final dehydration.

The system was thoroughly stirred to obtain a homogenous state and then unequal portions were poured into weighed beakers. After getting the weights of these portions, they were separately dehydrated by gentle heating and continuous stirring. The system became less opaque; the oil completely dry and water-white; and innumerable, fine dark, solid particles were seen suspended in it. These settled at the bottom when the oil was allowed to cool. When cool, the weight of the residue in each beaker was obtained:

	Beaker A *gms*	Beaker B *gms*
Weight of emulsion	95.8	110.5
Weight of residue	88.8	102.5
Weight of water globules	7.0	8.0

7.0 ÷ 95.8 = 7.29 per cent 8.0 ÷ 110.5 = 7.24 per cent

This particular reverse emulsion contained therefore a ratio of 7.26 per cent water globules to 92.72 per cent oil.

In all the eight washings of the dewatered cream the liquid system obtained was opaque, becoming less so after each washing owing to the loss of protein particles. At the end, the liquid system obtained appeared as when the quality oil was washed with either distilled or tap water. The substance that made the liquid system opaque was not dark to begin with but colorless. As the water globules evaporated, the fine solid particles left by the disappearing water globules changed color from white to dark. This showed that the organic component of the emulsifying system had undergone chemical changes. It was surmised as oxidative in nature. This was also observed when quality oil was washed with either salt solution or tap water.

When the cool oil was filtered, water-white oil was obtained; the dark, fine, solid particles remained in the filter paper. The residue was carefully washed to free it from oil. It was subjected to elemental degradation with heated fused sodium metal to obtain the corresponding sodium salts of sulfur, phosphorus, nitrogen and others which could be the molecular constituents of the emulsifying system. The presence of phosphorus and nitrogen was very positive and sulfur was starkly negative. The presence of chloride was positive. The ash of the dark, fine, solid particles was found positive for sodium. Sodium chloride is normally found in coconut water and, likewise, in coconut milk. The quality water-white oil was negative for chlorine, sodium, and sulfur, but positive for phosphorus and nitrogen.

The dark, solid, fine particles obtained from drying the quality oil after it had been washed with either salt solution or tap water a multiple of times were positive for phosphorus and nitrogen but starkly negative for sulfur. Their ash was positive for sodium and also for chloride. The water-globule emulsifying system was made up then of salt and a substance containing phosphorus and nitrogen which we would designate as a salt-phospholipid complex until we have definitely established its identity.

It would be fitting to restate here the observation that when quality water-white oil is washed a multiple of times with twice its volume in distilled water and dried by gentle heating and continuous stirring, no dark, fine, solid particles are produced. A water-in-oil emulsion is also obtained but the emulsifier of the water globules is redissolved in the oil. Only when the quality oil is washed with either salt solution or tap water, and evaporated with gentle heating and continuous stirring, that one gets dark, fine, solid particles.

This opens up the interesting problem of the effect of other manovalent salts, polyvalent salts, acids and bases on the emulsifier system of the oil globules of coconut milk and cream. The observation noted above that dewatered coconut cream or whole cream washed with twice its volume in distilled water produces a water-in-oil emulsion—the reverse of the emulsion system of coconut milk and cream—raises the question as to whether we are dealing with both oil globules and water globules. Our experience is that when dewatered cream or whole cream is washed with distilled water a water-in-oil emulsion is obtained and, after drying the oil, dark fine solid particles, which are positive for sodium and chlorine, are filtered. The salt is that which is naturally present in coconut milk. One would expect the salt and carbohydrates of the cream washed out before the oil globules coalesce to form the dispersing medium or continuous phase of the water-in-oil emulsion which leaves dark particles of salt-phospholipid complex when the oil is dried.

This appears to indicate that we have on hand a complex system. Even when the dewatered cream or whole cream is washed fourteen times with twice its volume of distilled water, the dark solid particles of salt-phospholipid complex is still present when the oil is dried. No free salt is present in the washed cream after a plurality of washing with distilled water. Only in combination with the phospholipid emulsifier system can it escape being washed out with the carbohydrates of the original cream. Washing the cream seven times with twice its volume in tap water would be sufficient to eliminate the three identified protein groups present and the other dissolved substances, such as salt and carbohydrates. But even after washing for 14 times with distilled water, the salt is still to be found associated with the emulsifier system of the water globules.

When the cream is washed longer, a better emulsion is obtained as reflected in the higher amount of water globules present. When cream is washed fourteen times, no oil layer separates on top. The whole body is an emulsion which appears like a soft jelly mass. No extraneous water accumulates at the bottom of the container when the emulsion is allowed to solidify in the refrigerator. The extraneous water, if any is present, is eliminated on kneading.

We proceeded with another experiment in which 500 cc of coconut cream from four nuts were washed ten times with twice its volume in tap water. To avoid the loss of much cream, an hour was allowed to pass before the lower aqueous layer was discharged. The opaqueness of the cream lessened as the protein was washed away, out at the ninth washing the washed cream was still opaque although not as dense as at the start. The opaqueness must be due to the remaining emulsifier.

At the end of the washing, the upper layer was allowed to release as much of its extraneous water as possible and then solidified for kneading. The solid oil in time became soft, and when this occurred it was cooled to harden for further kneading. Kneading stopped when all traces of extraneous water had disappeared. The solid mass was liquefied by gentle heating to separate any extraneous water left and then thoroughly mixed to obtain a homogenous body. This was divided into two unequal portions, placed in beakers to wiegh, and the mass of each was determined. Each beaker was then heated gently and stirred continuously to evaporate the water in the water globules and prevent bumping which could lead in the loss of oil.

As the water globules disappeared, they left behind them fine, dark, solid particles. The dark, fine solids settled at the bottom. The weight of the residue in each beaker was obtained by deducting the weight of the dry oil from the weight of the emulsion.

	Beaker A *gms*		Beaker B *gms*
Weight of emulsion	126.3	Weight of emulsion	145.6
Weight of dry oil	114.1	Weight of dry oil	131.5
Weight of water in water globules	12.2	Weight of water globules	14.1
12.2 ÷ 114.1 = 10.692 per cent		14.1 ÷ 131.5 = 10.72 per cent	

Cream from two nuts was washed 14 times with twice its volume in distilled water. A period of thirty minutes was allowed after every two successive washings to allow the two immiscible liquids to separate. At the end of the 14th washing, the thick emulsion, which was the top layer, was separated from the lower aqueous layer, transferred to a beaker, and frozen solid until it could be kneaded. A very small amount of extraneous water appeared after the kneading operation. The mass was gently melted and stirred to become homogenous, then separated into two predetermined unequal portions. Each portion was separately and gently heated to evaporate the water globules while stirring was done continuously. After cooling, and after the fine dark solid particles had accumulated at the bottom, the dry oil was weighed:

	Portion A *gms*	Portion B *gms*
Weight of emulsion	43.3	56.3
Weight of dry oil	37.5	48.9
Weight of water in water globules	5.8	7.4

5.8 ÷ 37.5 = 15.47 per cent   7.4 ÷ 48.9 = 15.14 per cent

DISCUSSION

Coconut cream separates by gravity from the aqueous phase of the emulsion and both layers simulate the opaque appearance of dairy cream and skim milk. The opaqueness is more intense in the cream layer. The protein content of the cream layer is a little less than three times that of the skim milk. After one hour gravity separation, the cream skim milk still has a volume bigger than the total volume of all the oil globules in it, and this cream skim milk contains more proteins than the skim milk.

Coconut cream becomes churnable(4) when the oil globules are chilled or solidified for a time at about 8°C and churning separates the cream skim milk. We have washed the kneaded solid mass with water held at 16°C and found the washing had less protein than the skim milk when the volume of washing was equal to half the volume of the original cream. It is possible to exhaust all the proteins and dissolved substances originally present in the original coconut cream by washing with distilled or tap water. In an earlier work[4] the carbohydrates and proteins had been exhausted from the cream by washing it several times with salt solution. The solution dissolved the proteins, leaving a quality water-white oil after the oil was dried with heat. It is our experience that whenever the proteins are not totally eliminated we always get an odorous yellowish oil upon heating it to dry. The odor is similar to that of pork lard. This gives us the impression that odor and color arise from the heated protein as the oil is being dried. When the cream is exhausted of all known proteins we always get water-white oil.

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[4] Birosel and Gonzales, loc. cit.

When salt solution is used for eliminating proteins and dissolved substances from the cream, there is left in the dry oil minute, dark, solid particles which formerly were the globule membrane of the water globules dispersed in the continuous phase of the emulsion. Continuous heating and stirring of the oil gives these particles a darker color; but when these are filtered a water-white oil is obtained.

A nut invariably gives about 0.3 gram of the solid residue. The ash of this solid residue shows positive flame test for sodium and its solution gives a copious precipitate of silver chloride. On decomposing the solid with heated sodium metal, the filtered solution gives positive test for phosphorus and nitrogen. Sulfur has never been identified in the various tests that were made. This is quite surprising because the three different proteins found in coconut milk contain the nutritionally important amino acid mentionine, which includes sulfur in its molecular composition.

Because of the absence of this element in the salt-emulsifier complex, we are tempted to state categorically that the emusifier in coconut milk and coconut cream is an organic substance containing phosphorus and nitrogen, which are not present in the structural composition of the molecules of fats and oils and none of the known proteins is combined with it. This view does not preclude the presence of unidentified protein with no menthionine or sulfur-bearing amino acid in its molecular composition. Associated with the salt, this substance darkens in color in an oil emulsion which is heated and continuously stirred to dry the oil. When salt solution, distilled water or tap water is used in washing the oil with vigorous shaking of the immiscible liquid, the result is an opaque emulsion and an opaque lower layer of the heavier liquid component. Undoubtedly, the natural emulsifier contributes to the opaque characteristics of coconut milk and coconut cream, and the impression that suspended and colloidal protein in milk give the opaque characteristics cannot be true.

The coconut milk or coconut cream or dairy milk or dairy cream is a natural emulsion of oil-in-water, but on washing the cream with salt solution, tap water, or distilled water, the emulsion is reversed giving us the water-in-oil type of emulsion. Likewise, when quality oil is washed with salt solution or tap water, we obtain a water-in-oil emulsion with the same natural emulsifier, but it is now what we may term a "salt-phospholipid complex" until we can fully identify and establish its structural formula.

The formation or appearance of a salt-phospholipid complex is understandable in the case of washing with salt solution, but it is rather hard to visualize its formation when tap water is used. It is harder to comprehend when distilled water is used as the vehicle to get rid of the proteins and dissolved substances in the aqueous phase of the coconut cream emulsion. However, sodium chloride is a normal constituent of the mineral component of dissolved substances in the natural coconut milk emulsion. On washing quality oil with salt solution or tap water a plurality of times to get rid of the dissolved emulsifier, and drying the oil with heat, there is always a solid residue left and this darkens in color as heating and stirring are continued. When distilled water is used for washing quality water-white coconut oil, the resultant emulsion is opaque and appears whitish, but on drying the oil by heat with continuous stirring no solid residue is obtained; the emulsifier appears to have redissolved in the oil.

It takes more washing with distilled water to release the emulsifier from the oil, than with salt solution and tap water. When the reversed emulsion state is formed and the system is allowed to stand, the water globules instead of rising, sink to form a distinct layer below, the bigger ones settling ahead of the smaller. These globules do not coalesce no matter how long the emulsion is allowed to stand. Stirring or shaking the emulsion system will disperse these globules in the oil phase. When quality oil is washed with salt solution, tap water, or distilled water, the washings are always opaque and the substance that makes for opacity does not settle down at the bottom of the container no matter how long it is kept.

Coconut butter and dairy butter contain water, the latter about 18 per cent and the former as low as 8.7 per cent when thoroughly kneaded. A portion of the water that is present in coconut butter appears to be in the form of globules combined with the salt-phospholipid complex emulsifier system, for no extraneous water accumulates at the bottom when the coconut butter is gently melted or allowed to warm up to room temperature which is always higher than the melting temperature of coconut oil, which is 27.4°C. The water in coconut butter is distributed between the proteins left in the butter and the water globules. When dewatered cream was washed eight times with twice its volume in salt solution and the extraneous water separated by careful kneading, the amount of water globules in the water-in-oil emulsion was found to be 4.4 per cent. The water present in coconut butter would then appear to be almost evenly distributed between the proteins in it and the water globules if one can accept the thesis that coconut butter is a water-in-oil type of emulsion. The water held by the proteins may be designated as "bound" water.

SUMMARY

1. Coconut cream has been successfully washed with salt solution, tap water, and distilled water to eliminate suspended and dissolved proteins, dissolved sugars and salts and produce a water-in-oil emulsion, which is the reverse of the oil-in-water type of emulsion of coconut milk and cream.

2. The quality water-white oil obtained from coconut cream gives also the water-in-oil type of emulsion when washed with salt solution or tap water or distilled water.

3. On drying the oil obtained by washing coconut cream a multiple of times with either salt solution, tap water or distilled water, fine, dark, solid particles, which are the collapsed membrane walls of innumerable water globules in the water-in-oil emulsion, settle at the bottom of the container. On filtering, water-white oil is obtained. The oil always has color and odor when the proteins are not completely washed out.

4. Fine, dark, solid particles are obtained on drying the quality oil that has been washed with either salt solution or tap water. No solid residue is obtained when the quality oil is washed with distilled water. This indicates that the material of the globule membrane redissolves in the oil.

5. The dark, solid, fine particles obtained by washing coconut cream multiple of times and the dark, solid, fine particles obtained by washing quality oil from the washed cream are both found to contain phosphorus and nitrogen. Sodium and chlorine are also found, but the salt is the natural salt in coconut milk and in the solution and tap water used in washing. The only source of the phosphorus and nitrogen is the natural

emulsifier system of coconut milk and cream. Sulfur is markedly negative in all the elemental analyses made, which means that the emulsifier system in coconut milk and cream is not a phospholipid protein but rather a salt-phospholipid complex.

6. Although the cream has been thoroughly washed of proteins and dissolved substances, the natural emulsifier of coconut milk and cream has the properties of forming a white opaque emulsion of water-in-oil and of adding and retaining sodium chloride even when the oil is rendered dry by heating and yields dark, fine, solid particles. This behavior is interesting and may lead to the identification of the natural emulsifier system of coconut milk and cream.

7. Besides the dispersed phase, like oil globules and protein particles, the emulsifier system of any milk contributes to the white opaque characteristics of milk.

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COMPARATIVE ANALYTICAL DATA OF SOME PHILIPPINE FRUITS

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One of the most important changes which occurs in fruits during maturation is the progressive softening of the flesh. Kertesz(9) cited various investigators who reported that this softening is generally associated with changes in pectic substances, pH value, acidity, soluble solids, total solids, ascorbic acid, and other constituents. Consequently, fruit tissue may contain high or low proportion of these constitutents depending upon its degree of maturity.

Each of the aforementioned components has its significance in the fruit processing industry. A knowledge of the acidity, pH value, and pectic constituents of fruits is of great importance particularly in the production of jellies and jams, whose textures are determined by the hydrogen-ion concentration of the pectin-sugar gel; in the preparation of fermented fruit products; in the clarification and stabilization of fruit juices; in the utilization and control of microorganism; and in many other fruit processing operations.

In the manufacture of fruit juices, jams, jellies, and other fruit preserves, blending of various fruits is frequently practiced. Fruits of different varieties and maturity may be blended to control the acid, soluble solids, pectin, and consequently the organoleptic and keeping quality of the finished product. Fruits for jelly preparation for example, should contain sufficient acid, sugar, and pectin to yield a good jelly. Some fruits especially at a certain stage of maturity, contain enough of both pectin and acid for this purpose. Others, however, are deficient in one or the other, while still others are deficient in both substances.

The pectic substances and pH value of fruits also play an important role in fruit juice technology. Some juices are cloudy and colloidal, and in such cases, the stabilizing effect of pectin is necessary. Its role in processing of tomato fruit products cannot be overemphasized. Investigations by Kertesz(10) indicated that pectic materials contribute greatly to the consistency and thickness of tomato juice and catsup. Luh, et al.(11)

reported that the ripeness level of tomatoes has a great effect on the consistency of tomato juice.

Fruits are very good sources of ascorbic acid, the anti-scorbutic vitamin. In addition to its nutritive value, this vitamin has also a preserving action in retaining the natural flavor, color and aroma of frozen packed fruits, canned fruits and fruit juices during storage.(8, 17) Bauerfeind, et al.(3, 4) reported the anti-oxidant property of ascorbic acid in the prevention of browning of unprocessed cut fruits.

Literature abounds in reports giving the chemical constituents of most nontropical fruits. Several workers, including Hughes and Maunsell,(7) Money,(12) Money and Christian(13) have compiled and presented analytical data on some of the common nontropical fruits, such as pear, apple, peach, cherry, etc.

No comparative analytical data of the chemical composition of locally grown ripe and unripe fruits have yet been reported. However, some Philippine fruits with their corresponding pectin content were reported by various investigators.(1, 16, 18) Rongo and Quiatson(15) have devoted most of their pectic investigations on citrus and a few other fruits.

It is the object of this study to obtain data on some of the important constituents and physical properties for some of the common Philippine fruits. Analytical results will be a source of information for home and commercial producers of processed fruit products. This study will also show which local fruits are good sources of Vitamin C and which can be utilized as raw materials for the commercial manufacture of pectin, citric acid, dehydrated fruit products, jams, jellies, and other processed fruit products.

MATERIALS AND MEHODS

Selection and preparation of materials.—Fruit samples obtained from local markets and various fruit growers, were selected and sorted into two stages of maturity (ripe and unripe) as observed visually. Analyses of the various constituents were done on the whole fruit, juice, pulp, or the peelings as may be necessary.

Pectin analysis.—The various pectic solubility fractions which included the water-soluble, oxalate-soluble and acid-soluble fractions were determined by the method described by Peter, et al.(14)

Acidity number.—The method used for acidity number determination was a modification of a procedure described by

Gould.(6) Accurately weighed amounts of fruit samples were diluted with distilled water, mixed thoroughly and titrated with standard alkali using phenolphatalein as indicator. For highly colored fruits, the end point was determined by using the Bechman pH meter model G. The results for citrus fruit were expressed as grams citric acid per 100 grams of sample. For other fruits, results were given as acidity number; i.e., the number of milliliters of 0.1 N NaOH required to neutralize 100 grams of sample.

pH value.—Measurements were conducted directly on the samples by the use of the Beckman pH meter Model G.

Total solids.—The A.O.A.C. method of analyses(2) was followed for total solids determination.

Soluble solids.—The Zeiss-Opton refractometer was used to measure the soluble solids on the juice alone.

Ascorbic acid.—The Bolin and Book Modification of the Roe and Oesterling Colorimeter Method(5) was used for ascorbic acid determination.

RESULTS AND DISCUSSION

Analytical results for the various fruit components analyzed are presented in Table 1. The pH value of the fruits analyzed ranged from pH 2.0 to 6.8. Most fruits which are of very low pH are correspondingly high in acidity number. These include the ripe and unripe fruits of *bignay, dalanghita* (var. tison and taikat), *dayap, balimbing, katmon, istroberi, lanzones, lokwat, yambo, pasyonaria, kolobot, serali, siniguelas amerikano* and the different varieties of unripe *manga.* Consequently, they are quite easily heat-processed. In jams and jelly making, fruits with high acidity number would make good combination with other fruits that lack acid.

A number of less-acid fruits analyzed showed a decrease in pH and an increase in acidity when they ripen. This is particularly true with the different varieties of bananas analyzed. The same holds true for *anonas, atis, mabolo, kalabasa, kamatsili, canistel, abokado, biriba, langka, papaya,* and others.

Compared with the unripe fruits, a higher soluble solid concentration and lower total solid content were observed in most of the ripe fruits.

Except for *kalabasa* and the peelings of *dalanghita* (var. tison) and of *kolobot,* all fruits showed a higher value for protopectin or the acid-soluble pectin fraction for the unripe than for the

TABLE 1.—*Comparative analytical data of some Philippine ripe and unripe fruits.*

Scientific name	Local name	English name	Parts used	pH	Acidity number	Soluble solids	Total solids	Ascorbic acid
					ml 0.1 N NaOH/100gm	*gm/100 gm*	*gm/100 gm*	*mg/100 gm*
1. *Persea Americana* Mill.	Abokado, berde	Avocado, green	Pulp, ripe	5.8	22.3	5.0	14.08	7
			Pulp, unripe	6.0	18.4	5.5	17.29	5
2. *Anona reticulata* Linn.	Anonas	Custard apple	Pulp, ripe	4.2	76.0	24.0	34.10	59
			Peelings, ripe	4.6	81.6	------	37.19	29
			Pulp, unripe	6.6	29.5	------	28.49	15
			Peelings, unripe	5.5	44.6	------	38.80	29
3. *Anona squamosa* Linn.	Atis	Sugar apple, sweet sop.	Pulp, ripe	5.0	47.3	21.0	32.97	29
			Pulp, unripe	6.5	18.6	8.0	34.29	37
4. *Averrhoa carambola* Linn.	Balimbing	Carambola	Whole fruit, ripe	4.0	24.8	9.0	10.89	37
			Whole fruit unripe	3.9	30.1	6.0	9.01	33
5. *Psidium guajava* Linn.	Bayabas, berde	Guava, green	Whole fruit, ripe	3.9	100.4	11.0	22.99	123
			Whole fruit, unripe	3.9	123.3	9.0	16.93	88
6. *Psidium guajava* Linn.	Bayabas, pula	Guava, red	Whole fruit, ripe	4.2	87.9	18.0	31.92	64
			Whole fruit, unripe	4.7	29.7	1.5	23.89	80
7. *Rollinia orthopetala* A.DC	Biriba	------	Pulp, ripe	4.6	48.3	9.0	14.92	9
			Peelings, ripe	5.4	------	------	18.03	20
			Pulp, unripe	5.9	15.3	7.5	11.26	17
			Peelings, unripe	5.5	------	------	16.12	21
8. *Antidesma bunius* (Linn.) Spreng.	Bignay	------	Whole fruit, ripe	2.9	442.1	4.5	16.35	9
			Whole fruit, unripe	2.8	461.6	4.0	18.93	12
9. *Chrysophyllum cainito* Linn	Kaimito, berde	Star apple, green	Pulp, ripe	5.8	13.7	15.0	18.90	4
			Pulp, unripe	5.4	27.5	8.5	20.96	21
10. *Chrysphyllum cainito* Linn.	Kaimito, murado	Star apple, purple	Pulp, ripe	5.4	24.1	14.5	18.89	5
			Pulp, unripe	5.3	47.6	1.5	16.36	25
11. *Cucurbita maxima* Duchesne	Kalabasa	Squash fruit	Pulp, ripe	6.2	9.8	10.0	13.19	16
			Pulp, unripe	6.5	9.1	5.0	7.20	6
12. *Citrus microcarpa* Bunge.	Kalamansi	------	Juice, ripe	2.9	5.03*	7.0	8.24	36
			Peelings, ripe	3.3	1.20*	------	21.87	46
			Juice, unripe	2.4	7.01*	7.0	8.62	39
			Peelings, unripe	3.3	1.08*	------	28.89	71
13. *Lycopersicum esculentum* Mill.	Kamatis	Tomato	Whole fruit, ripe	4.2	94.1	4.0	6.36	17
			Whole fruit, unripe	4.4	87.6	3.5	7.43	16
14. *Lycopersicum esculentum* Mill. var. *pyriforme* Alef.	Kamatis	Pear tomato	Whole fruit, ripe	3.9	237.3	9.5	17.75	32
15. *Pithecolobium dulce* (Roxb.) Benth.	Kamatsili	Aztec kwamochill	Pulp, ripe	4.5	120.6	17.5	24.27	185
			Pulp, unripe	4.8	96.4	19.0	26.96	180
16. *Averrhoa bilimbi* Linn.	Kamyas	Bilimbi	Whole fruit, ripe	2.0	201.6	4.0	5.19	15

17. *Anacardium occidentale* Linn.	Kasuy	Cashew	Whole fruit, unripe	1.9	231.8	3.5	6.27	9
			Pulp and skin, ripe	4.4	49.2	10.0	17.61	223
			Pulp and skin, unripe	4.1	73.1	8.0	40.62	172
18. *Dillenia philippinensis* Rolfe.	Katmon	Philippine dillenia	Pulp, ripe	2.8	280.4	6.5	10.61	5
			Pulp, unripe	3.3	160.3	5.5	17.52	5
19. *Citrus hystrix* DC. var. *torosa* (Blanco) Wester.	Kalobot		Juice, ripe	2.8	5.95*	8.0	8.72	102
			Peelings, ripe	3.7	1.92*		36.37	66
			Juice, unripe	2.3	6.37*	8.0	10.02	56
			Peelings, unripe	4.3	1.72*		35.59	76
20. *Benincasa hispida* (Thunb.) Cogn.	Kundol	Waxgourd	Pulp, unripe	4.9	11.7	2.0	4.36	18
21. *Citrus nobilis* Lour.	Dalanghita (Czinkum)	Mandarin	Juice, ripe	3.7	0.74*	10.0	11.49	27
			Peelings, ripe	4.2	0.32*		22.43	72
			Juice, unripe	2.7	0.97*	8.5	10.70	28
			Peelings, unripe	4.1	2.79*		27.08	24
22. *Citrus nobilis* Lour.	Dalanghita (Taikat)	Mandarin	Juice, ripe	3.4	0.91*	9.0	10.71	49
			Peelings, ripe	3.9	0.43*		30.74	76
			Juice, unripe	2.2	3.11*	8.0	10.23	
			Peelings, unripe	3.1	0.97*		26.26	
23. *Citrus nobilis* Lour.	Dalanghita (Tison)	Mandarin	Juice, ripe	2.9	2.64*	10.0	10.52	32
			Peelings, ripe	4.0	3.01*		20.51	74
			Juice, unripe	2.9	1.45*	9.0	9.07	29
			Peelings, unripe	4.0	2.75*		18.41	55
24. *Muntingia calabura* Linn.	Datiles		Whole fruit, ripe	5.8	38.4	15.0	21.77	141
			Whole fruit, unripe	6.0	41.4		22.99	70
25. *Citrus aurantifolia* (Christm.) Swingle.	Dayap	Lime	Pulp and juice, ripe	2.0	6.54*	7.0	11.08	18
			Peelings, ripe	2.9	2.99*		24.63	50
			Pulp and juice, unripe	2.4	9.56*	7.0	9.92	36
			Peelings, unripe	2.9	3.51*		25.51	43
26. *Sizygium cumini* (Linn.) Skeels.	Duhat	Black plum Java plum.	Pulp and skin, ripe	3.6	162.9	13.0	16.64	12
			Pulp and skin, unripe	4.1	115.3	8.0	27.84	10
27. *Punica granatum* Linn.	Granada	Pomegranate	Pulp, ripe	3.9	232.6	9–0	27.95	111
			Seeds, ripe	4.3	52.1		23.54	18
			Pulp, unripe	4.4	521.2	7.0	31.58	187
			Seeds, unripe	5.0	50.3		12.39	10
28. *Anona muricata* Linn.	Guwayabano	Soursop	Pulp, ripe	3.9	24.0	10.0	15.90	18
			Pulp, unripe	4.8	15.3	7.5	16.97	17
29. *Fragraria vesca* Linn.	Istroberi	Strawberry	Whole fruit, ripe	3.2	146.6	7.0	10.56	68
30. *Artocarpus heterophylus* Lam.	Langka	Jackfruit	Pulp, ripe	4.5	64.8	19.5	29.42	5
			Pulp, unripe	5.1	19.0	4.5	11.08	13
31. *Lansium domesticum* Correa.	Lansones	Lanzon	Pulp, ripe	3.0	370.8	14.0	18.74	2
			Pulp, unripe	3.7	713.1	9.0	13.08	3
32 *nia polycephaloides* C.B. Rob.	Lipoti		Whole fruit, ripe	2.9	451.2	11.0	18.09	19
			Without seeds, unripe	2.8	530.7	4.5	18.19	16
33. *Eriobotrya japonica* Lindle.	Lokwat		Pulp, ripe	3.1	202.2	8.0	13.35	7
			Peelings, ripe	3.5	128.2		16.41	
			Pulp, unripe	3.0	438.2	6.0	10.18	8
			Peelings, unripe	3.4	217.2		19.73	
34. *Diospyros discolor* Wild.	Mabolo	Ebony	Pulp, ripe	5.8	10.2	10.5	23.35	18

* Citric acid per 100 gm.

TABLE 1.—*Comparative analytical data of some Philippine ripe and unripe fruits.*—Continued.

Scientific name	Local name	English name	Parts used	pH	Acidity number	Soluble solids	Total solids	Ascorbic acid
					ml 0.1 N NaOH*/100gm*	*gm/100 gm*	*gm/100 gm*	*mg/100 gm*
35. *Syzygium samarangense* (Blume)	Makopa	Curacao apple	Pulp, unripe	5.9	9.2	6.0	20.68	12
			Whole fruit, ripe	4.6	28.9	6.5	11.16	14
			Without seeds, unripe	4.2	28.5	5.5	10.40	15
36. *Mangifera indica* Linn.	Mangga, kalabaw	Mango	Pulp, ripe	4.6	54.5	21.0	23.52	52
			Pulp, unripe	3.0	693.6	10.5	15.73	63
37. *Mangifera indica* Linn.	Mangga, Indiyan	Indian Mango	Pulp, ripe	4.4	49.2	18.0	20.35	22
			Pulp, unripe	3.5	167.6	6.0	15.89	82
38. *Mangifera indica* Linn.	Mangga, piko	Mango	Pulp, ripe	4.9	34.5	15.0	16.76	87
			Pulp, unripe	2.8	417.1	6.0	12.91	57
39. *Cucumis melo* Linn.	Milon, kastila	Cantaloupe Spanish melon.	Pulp, ripe	5.2	37.2	4.0	4.71	30
			Pulp, unripe	5.0	19.4	3.5	4.39	24
40. *Cucumis melo* Linn.	Milon	Cantaloupe, round smooth var.	Pulp, ripe	6.0	9.8	6.0	8.43	23
			Pulp, unripe	5.0	12.6	4.5	8.12	23
41. *Citrullus vulgaris* Schrad.	Pakwan	Water melon	Pulp, ripe	4.9	8.7	5.1	6.66	9
			Pulp, unripe	5.0	11.9	5.0	4.79	6
42. *Carica papaya* Linn.	Papaya	Papaw	Pulp, ripe	5.3	31.1	8.5	9.34	35
			Pulp, unripe	5.7	28.6	5.0	7.50	18
43. *Passiflora edulis* Sims.	Pasionaria	Passion fruit	Juice, ripe	3.0	514.5	16.5	19.97	40
			Juice, unripe	2.9	818.9	12.5	16.51	8
44. *Canarium ovatum* Engl.	Pili	Pili	Pulp, ripe	5.0	113.2	12.0	32.12	29
			Pulp, unripe	4.9	45.3	------	25.36	27
45. *Ananas comosus* (Linn.) Merr.	Pinya	Native pineapple	Pulp, ripe	3.6	105.8	16.0	18.25	15
			Pulp, unripe	3.7	70.3	10.0	12.89	15
46. *Artocarpus communis* Forst.	Rimas	Breadfruit	Pulp, ripe	6.5	19.0	22.0	29.75	12
			Pulp, unripe	6.8	19.9	6.0	29.30	30
47. *Musa sapientum* Linn.	Saguing, bungulan	Banana	Pulp, ripe	4.7	94.1	21.0	26.52	14
			Pulp, unripe	5.9	61.1	2.5	32.25	13
48. *Musa errans* (Blanco) Teodoro var. *Botoan* Teodoro.	Saguing, butuan	Banana	Pulp, ripe	4.7	34.6	19.5	27.06	18
			Pulp, unripe	6.1	10.6	13.0	39.53	32
49. *Musa sapientum* Linn.	Saguing, gloria	Banana	Pulp, ripe	4.6	84.1	27.5	36.04	17
			Pulp, unripe	5.7	33.7	15.0	37.44	18
50. *Musa sapientum* Linn.	Saguing, lakatan	Banana	Pulp, ripe	4.8	109.2	24.0	31.08	11
			Pulp, unripe	4.9	23.2	12.0	38.06	15
51. *Musa sapientum* Linn.	Saguing latundan	Banana	Pulp, ripe	4.3	81.9	27.0	32.92	14
			Pulp, unripe	6.3	11.8	6.0	34.19	16
52. *Musa sapientum* Linn.	Saguing, morado	Banana	Pulp, ripe	4.5	50.4	22.0	30.13	15
			Pulp, unripe	5.2	20.8	10.0	40.36	17
53. *Musa sapientum* Linn.	Saguing, saba	Banana	Pulp, ripe	4.4	82.2	28.0	28.48	29
			Pulp, unripe	5.9	21.8	11.0	42.67	37

54. *Musa sapientum* Linn.	Saguing, ternate	Banana	Pulp, ripe	4.8	77.0	28.0	36.89	25
			Pulp, unripe	5.2	53.7	13.0	38.93	18
55. *Tamarindus indica* Linn.	Sampalok	Tamarind	Pulp, ripe	2.2	------------	46.0	53.32	5
			Pulp, unripe	2.3	------------	12.0	18.78	9
56. *Sandoricum koetjape* (Burm f.) Merr.	Santol	------------	Pulp, ripe	3.4	210.9	14.0	15.46	25
			Pulp, unripe	3.3	223.5	11.0	21.07	19
57. *Flacourtia ramontchi* L'Herit.	Serali	Governor plum	Whole fruit, ripe	2.7	309.5	18.0	22.28	10
			Whole fruit, unripe	3.0	164.7	7.0	27.49	17
58. *Spondias purpurea* Linn.	Sineguelas	------------	Pulp and skin, ripe	3.5	58.3	11.0	17.60	37
			Pulp and skin, unripe	3.3	134.4	7.0	23.96	45
59. *Spondias cytherea* Son.	Sineguelas, amerikano.	Otaheite apple	Whole fruit, unripe	3.1	145.3	7.0	15.26	55
60. *Citrus maxima* (Burm.) Merr.	Suha	Pomelo	Pulp and juice, ripe	3.7	0.64*	8.0	9.35	42
			Peelings, ripe	4.9	1.65*	------------	22.34	62
			Pulp and juice, unripe	3.8	0.55*	7.0	12.83	110
			Peelings, unripe	4.8	0.36*	------------	25.07	277
61. *Ovaria rufa* Blume.	Susong kalabaw	------------	Pulp, ripe	3.9	95.4	6.5	13.54	13
			Pulp, unripe	4.5	71.1	8.0	24.96	14
62. *Lucuma nervosa* A. DC	Tiesa	Canistel	Pulp, ripe	5.5	48.2	30.5	41.01	33
			Pulp, unripe	5.7	34.8	16.5	40.01	40
63. *Achras zapota* Linn.	Tsiko	Sapodilla	Pulp and skin, ripe	5.3	21.7	16.0	28.55	61
			Pulp and skin, unripe	5.4	31.0	29.0	29.57	85
64. *Calocarpum sapota* (Jacq.) Merr.	Tsiko mamei	Marmalade plum	Pulp and skin, ripW	6.6	23.4	28.0	33.43	9
			Pulp and skin, unripe	5.8	25.1	15.5	39.48	49
65. *Syzydium malaccense* (Linn.) Merr. & Perry.	Yambo	Malay apple	Pulp and skin, ripe	3.1	105.4	5.0	7.34	21
			Pulp and skin, unripe	3.2	113.8	3.5	7.20	16

* Citrus acid per 100 gm.

TABLE 1.—*Comparative analytical data of some Philippine ripe and unripe fruits*—Continued.

Scientific name	Local name	English name	Parts used	Calcium pectate			
				Water-soluble pectin		Oxalate-soluble pectin	
				Fresh basis	Dry basis	Fresh basis	Dry basis
				gm/100 gm	*gm/100 gm*	*gm/100 gm*	*gm/100 gm*
1. *Persea Americana* Mill.	Abokado, berde	Avocado, green	Pulp, ripe	0.22	1.56	Traces	----
			Pulp, unripe	0.16	0.93	0.22	1.27
2. *Anona reticulata* Linn.	Anonas	Custard apple	Pulp, ripe	0.78	2.29	0.51	1.50
			Peelings, ripe	0.42	1.13	1.06	2.85
			Pulp, unripe	0.12	0.42	0.13	0.46
			Peelings, unripe	Traces	Traces	0.03	0.08
3. *Anona squamosa* Linn.	Atis	Sugar apple, sweet sop.	Pulp, ripe	0.74	2.24	0.54	1.64
			Pulp, unripe	0.50	1.46	0.32	0.93
4. *Averrhoa carambola* Linn.	Balimbing	Carambola	Whole fruit, ripe	0.63	5.87	0.14	1.29
			Whole fruit unripe	0.18	2.00	0.39	4.33
5. *Psidium guajava* Linn.	Bayabas, berde	Guava, green	Whole fruit, ripe	0.52	2.26	0.23	1.00
			Whole fruit, unripe	0.54	3.19	0.34	2.01
6. *Psidium guajava* Linn.	Bayabas, pula	Guava, red	Whole fruit, ripe	0.41	1.28	0.34	1.07
			Whole fruit, unripe	0.28	1.17	0.20	0.84
7. *Rollinia orthopetala* A.DC.	Biriba	----	Pulp, ripe	0.54	3.62	0.33	2.21
			Peelings, ripe	0.88	4.88	0.74	4.10
			Pulp, unripe	0.15	1.35	0.46	4.09
			Peelings, unripe	0.79	4.90	0.92	5.71
8. *Antidesma bunius* (Linn.) Spreng.	Bignay	----	Whole fruit, ripe	0.34	2.08	0.53	3.24
			Whole fruit, unripe	0.08	0.42	0.30	1.58
9. *Chrysophyllum cainito* Linn	Kaimito, berde	Star apple, green	Pulp, ripe	0.97	5.13	Traces	----
			Pulp, unripe	0.28	1.34	Traces	----
10. *Chrysphyllum cainito* Linn.	Kaimito, murado	Star apple, purple	Pulp, ripe	0.28	1.48	Traces	----
			Pulp, unripe	0.03	0.18	Traces	----
11. *Cucurbita maxima* Duchesne	Kalabasa	Squash fruit	Pulp, ripe	0.20	1.52	0.80	6.07
			Pulp, unripe	0.34	4.72	0.44	6.11
12. *Citrus microcarpa* Bunge.	Kalamansi	----	Juice, ripe	1.04	12.62	----	----
			Peelings, ripe	1.04	4.76	2.05	9.37
			Juice, unripe	0.33	3.83	----	----
			Peelings, unripe	0.42	1.45	0.61	2.11
13. *Lycopersicum esculentum* Mill.	Kamatis	Tomato	Whole fruit, ripe	0.12	1.89	0.03	0.47
			Whole fruit, unripe	0.06	0.81	0.11	1.48
14. *Lycopersicum esculentum* Mill. var. *pyriforme* Alef.	Kamatis	Pear tomato	Whole fruit, ripe	1.31	7.38	0.62	3.49
15. *Pithecolobium dulce* (Roxb.) Benth.	Kamatsili	Aztec kwamochill	Pulp, ripe	Traces	----	Traces	----
			Pulp, unripe	Traces	----	0.07	0.26

16. *Averrhoa bilimbi* Linn.	Kamyas	Bilimbi	Whole fruit, ripe	0.19	3.36	0.09	1.73
			Whole fruit, unripe	0.32	5.10	0.34	5.42
17. *Anacardium occidentale* Linn.	Kasuy	Cashew	Pulp and skin, ripe	0.08	0.45	0.13	0.74
			Pulp and skin, unripe	0.12	0.30	0.14	0.34
18. *Dillenia philippinenses* Rolfe	Katmon	Philippine dillenia	Pulp, ripe	0.07	0.66	0.68	6.41
			Pulp, unripe	0.29	1.66	0.09	0.51
19. *Citrus hystrix* DC. var. *torosa* (Blanco) Wester.	Kolobot		Juice, ripe	0.50	5.73		
			Peelings, ripe	1.95	5.36	2.45	6.74
			Juice, unripe	0.46	4.59		
			Peelings, unripe	1.02	2.87	1.83	5.14
20. *Benincasa hispida* (Thunb.) Cogn.	Kundol	Waxgourd	Pulp, unripe	0.16	3.67	0.27	6.19
21. *Citrus nobilis* Lour.	Dalanghita (Czinkum)	Mandarin	Juice, ripe	0.51	4.44		
			Peelings, ripe	1.36	6.06	2.76	12.30
			Juice, unripe	0.65	6.07		
			Peelings, unripe	1.29	4.76	1.48	5.47
22. *Citrus nobilis* Lour.	Dalanghita (Taikat)	Mandarin	Juice, ripe	0.27	2.52		
			Peelings, ripe	0.71	2.31	1.55	50.4
			Juice, unripe	0.41	4.01		
			Peelings, unripe	0.86	3.27	1.09	4.15
23. *Citrus nobilis* Lour.	Dalanghita (Tison)	Mandarin	Juice, ripe	0.78	7.41		
			Peelings, ripe	0.38	1.85	1.05	5.12
			Juice, unripe	0.27	2.98		
			Peelings, unripe	0.70	3.80	1.22	6.63
24. *Muntingia calabura* Linn.	Datiles		Whole fruit, ripe	0.36	1.65	0.40	1.84
			Whole fruit, unripe	0.22	0.96	0.33	1.44
25. *Citrus aurantifolia* (Christm.) Swingle.	Dayap	Lime	Pulp and juice, ripe	1.11	10.02		
			Peelings, ripe	0.41	1.66	2.03	8.24
			Pulp and juice, unripe	0.91	9.17		
			Peelings, unripe	0.31	1.22	1.10	4.31
26. *Sizygium cumini* (Linn.) Skeels	Duhat	Black plum Java plum	Pulp and skin, ripe	0.07	0.42	0.12	0.72
			Pulp and skin, unripe	Traces		Traces	
27. *Punica granatum* Linn.	Granada	Pomegranate	Pulp, ripe	0.52	1.86	0.54	1.93
			Seeds, ripe	0.79	3.36	0.83	3.53
			Pulp, unripe	0.42	1.33	0.47	1.49
			Seeds, unripe	0.50	4.04	0.31	2.50
28. *Anona muricata* Linn.	Guwayabano	Soursop	Pulp, ripe	0.45	2.83	0.69	4.34
			Pulp, unripe	0.32	1.89	0.39	2.30
29. *Fragraria vesea* Linn.	Istroberi	Strawberry	Whole fruit, ripe	0.35	3.31	0.16	1.52
30. *Artocarpus heterophylus* Lam.	Langka	Jackfruit	Pulp, ripe	0.70	2.38	0.33	1.12
			Pulp, unripe	0.20	1.81	0.35	3.16
31. *Lansium domesticum* Correa	Lansones	Lanzon	Pulp, ripe	0.30	1.60	0.14	0.75
			Pulp, unripe	0.28	21.4	0.22	1.68
32. *Eugenia polycephaloides* C.B. Rob.	Lipoti		Whole fruit, ripe	0.16	0.88	0.42	2.32
			Without seeds, unripe	0.30	1.65	0.14	0.77
33. *Eriobotrya japonica* Lindle.	Lokwat		Pulp, ripe	0.34	2.55	0.33	2.47
			Peelings, ripe	0.75	4.57	1.20	7.31
			Pulp, unripe	0.38	3.73	0.42	4.13
			Peelings, unripe	0.74	3.75	0.65	3.29

TABLE 1.—*Comparative analytical data of some Philippine ripe and unripe fruits.*—Continued.

Scientific name	Local name	English name	Parts used	Calcium Pectate			
				Water-soluble pectin		Oxalate-soluble pectin	
				Fresh basis	Dry basis	Fresh basis	Dry basis
				gm/100 gm	*gm/100 gm*	*gm/100 gm*	*gm/100 gm*
34. *Diospyros discolor* Willd.	Mabolo	Ebony	Pulp, ripe	0.89	3.81	Traces	------
			Pulp, unripe	0.28	1.35	Traces	------
35. *Syzygium samarangense* (Blume)	Makopa	Curacao apple	Whole fruit, ripe	0.25	2.24	0.32	2.87
			Without seeds, unripe	0.08	0.77	0.30	2.88
36. *Mangifera indica* Linn.	Mangga, kalabaw	Mango	Pulp, ripe	0.24	1.02	0.54	2.30
			Pulp, unripe	Traces	------	0.41	2.61
37. *Mangifera indica* Linn.	Mangga, Indiyan	Indian mango	Pulp, ripe	0.57	2.80	0.40	1.97
			Pulp, unripe	0.16	1.01	0.21	1.32
38. *Mangifera indica* Linn.	Mangga, piko	Mango	Pulp, ripe	0.55	3.28	0.15	0.90
39. *Cucumis melo* Linn.	Milon, kastila	Cantaloupe Spanish melon.	Pulp, unripe	0.07	0.54	0.04	0.31
			Pulp, ripe	0.22	4.67	0.17	3.61
40. *Cucumis melo* Linn.	Milon	Cantaloupe, round smooth, var.	Pulp, unripe	0.22	5.01	0.11	2.51
			Pulp, ripe	0.10	1.19	0.31	3.68
			Pulp, unripe	0.12	1.48	0.16	1.97
41. *Citrullus vulgaris* Schrad.	Pakwan	Water melon	Pulp, ripe	Traces	------	0.21	3.15
			Pulp, unripe	Traces	------	0.15	3.13
42. *Carica papaya* Linn.	Papaya	Papaw	Pulp, ripe	0.30	3.21	1.45	15.53
			Pulp, unripe	0.21	2.80	2.44	32.53
43. *Passiflora edulis* Sims.	Pasionaria	Passion fruit	Juice, ripe	0.18	0.90	------	------
			Juice, unripe	0.24	1.45	------	------
44. *Canarium ovatum* Engl.	Pili	Pili	Pulp, ripe	1.78	5.54	0.68	2.12
			Pulp, unripe	0.60	2.37	0.47	1.85
45. *Ananas comosus* (Linn.) Merr.	Pinya	Native pineapple	Pulp, ripe	0.33	1.81	0.13	0.71
			Pulp, unripe	0.24	1.86	0.42	3.26
46. *Artocarpus communis* Forst.	Rimas	Breadfruit	Pulp, ripe	1.61	5.41	0.14	0.47
			Pulp, unripe	1.76	6.01	0.32	1.09
47. *Musa sapientum* Linn.	Saguing, bungulan	Banana	Pulp, ripe	0.60	2.26	0.23	0.87
			Pulp, unripe	0.30	0.93	0.18	0.56
48. *Musa errans* (Blanco) Teodoro var. *Botoan* Teodoro.	Saguing, butuan	Banana	Pulp, ripe	0.68	2.51	0.30	1.11
			Pulp, unripe	0.74	1.87	0.55	1.39
49. *Musa sapientum* Linn.	Saguing, gloria	Banana	Pulp, ripe	0.32	0.89	0.10	0.28
			Pulp, unripe	0.30	0.80	0.04	0.11
50. *Musa sapientum* Linn.	Saguing, lakatan	Banana	Pulp, ripe	0.65	2.09	1.11	3.57
			Pulp, unripe	0.23	0.60	1.01	2.65
51. *Musa sapientum* Linn.	Saguing, lantundan	Banana	Pulp, ripe	0.26	0.79	0.22	0.67
			Pulp, unripe	0.31	0.91	0.24	0.70

52. *Musa sapientum* Linn.	Saguing, morado	Banana	Pulp, ripe	0.31	1.03	0.37	1.23
			Pulp, unripe	0.41	1.02	0.26	0.64
53. *Musa sapientum* Linn.	Saguing, saba	Banana	Pulp, ripe	0.49	1.72	0.75	2.63
			Pulp, unripe	0.47	1.10	0.37	0.87
54. *Musa sapientum* Linn.	Saguing, ternate	Banana	Pulp, ripe	0.30	0.81	0.21	0.57
			Pulp, unripe	0.23	0.59	0.19	0.49
55. *Tamarindus indica* Linn.	Sampalok	Tamarind	Pulp, ripe	Traces		Traces	
56. *Sandoricum koetjape* (Burm f.) Merr.	Santol		Pulp, unripe	0.09	0.48	0.08	0.43
			Pulp, ripe	0.91	5.89	0.54	3.49
57. *Flacourtia ramontchi* L'Herit.	Serali	Governor plum	Pulp, unripe	0.64	3.04	0.57	2.71
			Whole fruit, ripe	0.34	1.53	0.33	1.48
			Whole fruit, unripe	0.30	1.09	0.24	0.87
58. *Spondias purpurea* Linn.	Sineguelas		Pulp and skin, ripe	1.01	5.74	0.67	3.81
59. *Spondias cytherea* Son.	Sineguelas amerikano	Otaheite apple	Pulp and skin, unripe	0.62	2.59	0.59	2.46
			Whole fruit, unripe	0.42	2.75	0.31	2.03
60. *Citrus maxima* (Burm.) Merr.	Suha	Pomelo	Pulp and juice, ripe	0.35	3.74	0.35	3.77
			Peelings, ripe	0.97	4.34	1.49	6.61
			Pulp and juice, unripe	0.10	0.78	0.13	1.05
			Peelings, unripe	0.05	0.20	1.09	4.33
61. *Ovaria rufa* Blume	Susong kalabaw		Pulp, ripe	0.31	2.29	0.14	1.02
			Pulp, unripe	0.01	0.04	0.08	0.35
62. *Lucuma nervosa* A. DC	Tiesa	Canistel	Pulp, ripe	0.46	1.12	0.06	0.19
			Pulp, unripe	0.18	0.45	Traces	
63. *Achras zapota* Linn.	Tsiko	Sapodilla	Pulp and skin, ripe	0.77	2.70	0.54	1.88
64. *Calocarpum sapota* (Jacq.) Merr.	Tsiko mamei	Marmalade plum	Pulp and skin, unripe	0.46	1.56	0.26	0.88
			Pulp and skin, ripe	0.63	1.88	0.16	0.40
65. *Syzydium malaccense* (Linn.) Merr. & Perry.	Yambo	Malay apple	Pulp and skin, unripe	0.27	0.68	1.38	3.59
			Pulp and skin, ripe	0.32	4.36	0.41	5.57
			Pulp and skin, unripe	0.17	2.36	0.25	3.44

TABLE 1.—*Comparative analytical data of some Philippine ripe and unripe fruits.*—Continued.

Scientific name	Local name	English name	Parts used	Calcium Pectate			
				Acid-soluble pectin		Total pectin	
				Fresh basis	Dry basis	Fresh basis	Dry basis
				gm/100 gm	*gm/100 gm*	*gm/100 gm*	*gm/100 gm*
1. *Persea americana* Mill.	Abokado, berde	Avocado, green	Pulp, ripe	Traces		0.22	1.56
			Pulp, unripe	0.20	1.16	0.58	3.36
2. *Anona reticulata*	Anonas	Custard apple	Pulp ripe	0.72	2.11	2.01	5.90
			Peelings, ripe	0.66	1.77	2.14	5.75
			Pulp, unripe	1.78	6.25	2.03	7.13
			Peelings, unripe	1.19	3.07	1.22	3.15
3. *Anona squamosa* Linn.	Atis	Sugar apple, sweet sop.	Pulp, ripe	0.01	0.03	1.29	3.91
			Pulp, unripe	0.88	2.57	1.70	4.96
4. *Averrhoa carambola* Linn.	Balimbing	Carambola	Whole fruit, ripe	0.34	3.12	1.11	10.19
			Whole fruit, unripe	0.42	4.66	0.99	10.99
5. *Psidium guajava* Linn.	Bayabas, berde	Guava, green	Whole fruit, ripe	0.66	2.87	1.41	6.13
			Whole fruit, unripe	1.04	6.14	1.92	11.34
6. *Psidium guajava* Linn.	Bayabas, pula	Guava, red	Whole fruit, ripe	0.77	2.41	1.52	4.76
			Whole fruit, unripe	0.70	2.93	1.18	4.94
7. *Rollinia orthopetala* A. DC.	Bariba		Pulp, ripe	0.61	4.09	1.48	9.92
			Peelings, ripe	1.06	5.88	2.68	14.86
			Pulp, unripe	0.87	7.73	1.48	13.15
			Peelings, unripe	1.65	10.24	3.36	20.85
8. *Antidesma bunius* (Linn.) Spreng.	Bignay		Whole fruit, ripe	0.50	3.06	1.37	8.38
			Whole fruit, unripe	0.72	3.80	1.10	5.80
9. *Chrysophyllum caimito* Linn.	Kaimito, berde	Star apple, green	Pulp, ripe	0.10	0.53	1.07	5.66
			Pulp, unripe	0.31	1.48	0.59	2.82
10. *Chrysophyllum cainito* Linn.	Kaimito, murado	Star apple, purple	Pulp, ripe	0.21	1.11	0.49	2.59
			Pulp, unripe	0.66	4.03	0.69	4.21
11. *Cucurbita maxima* Duchesne.	Kalabasa	Squash fruit	Pulp, ripe	0.63	4.78	1.63	12.37
			Pulp, unripe	0.32	4.44	1.10	15.27
12. *Citrus microcarpa* Bunge.	Kalamansi		Juice, ripe			1.04	12.62
			Peelings, ripe	5.43	24.83	8.52	38.96
			Juice, unripe			0.33	3.83
			Peelings, unripe	7.05	24.40	8.08	27.96
13. *Lycopersicum esculentum* Mill.	Kamatis	Tomato	Whole fruit, ripe	0.06	0.94	0.21	3.30
			Whole fruit, unripe	0.55	7.40	0.72	9.69
14. *Lycopersicum esculentum* Mill. var. *pyriforme* Alef.	Kamatis	Pear tomato	Whole fruit, ripe	1.10	6.20	3.03	17.07
15. *Pithecloblum dulce* (Roxb.) Benth.	Kamatsili	Aztec kwamochill	Pulp, ripe	0.96	3.96	0.96	3.96
			Pulp, unripe	1.14	4.23	1.21	4.49

16. *Averrhoa bilimbi* Linn.	Kamyas	Bilimbi	Whole fruit, ripe	0.45	8.67	0.73	14.06
			Whole fruit, unripe	0.46	7.34	1.12	17.86
17. *Anacardium occidentale* Linn.	Kasuy	Cashew	Pulp and skin, ripe	0.35	1.99	0.56	3.18
			Pulp and skin, unripe	0.39	0.96	0.65	1.60
18. *Dillenia philippinensis* Rolfe.	Katmon	Philippine dillenia	Pulp, ripe	0.42	3.96	1.17	11.03
			Pulp, unripe	0.68	3.88	1.06	6.05
19. *Citrus hystrix* DC. var. *torosa* (Blanco) Wester	Kolobot	----	Juice, ripe	----	----	0.50	5.73
			Peelings, ripe	5.40	14.85	9.80	26.95
			Juice, unripe	----	----	0.46	4.59
			Peelings, unripe	4.11	11.61	6.96	19.56
20. *Benincasa hispida* (Thunb.) Cogn.	Kundol	Waxgourd	Pulp, unripe	0.61	13.99	1.04	23.85
21. *Citrus nobilis* Lour.	Dalanghita (Czinkum)	Mandarin	Juice, ripe	----	----	0.51	4.44
			Peelings, ripe	3.29	14.67	7.41	33.03
			Juice, unripe	----	----	0.65	6.07
			Peelings, unripe	5.44	20.09	8.21	30.32
22. *Citrus nobilis* Lour.	Dalanghita (Taikat	Mandarin	Juice, ripe	----	----	0.27	2.52
			Peelings, ripe	2.69	8.75	4.95	16.10
			Juice, unripe	----	----	0.41	4.01
			Peelings, unripe	5.53	21.06	7.48	28.48
23. *Citrus nobilis* Lour.	Dalanghita (Tison)	Mandarin	Juice, ripe	----	----	0.78	7.41
			Peelings, ripe	3.29	16.04	4.72	23.01
			Juice, unripe	----	----	0.27	2.98
			Peelings, unripe	2.23	12.11	4.15	22.54
24. *Muntingia calabura* Linn.	Datiles	----	Whole fruit, ripe	0.70	3.22	1.46	6.71
			Whole fruit, unripe	0.96	4.18	6.58	28.62
25. *Citrus aurantifolia* (Christm.) Swingle.	Dayap	Lime	Pulp and juice, ripe	----	----	1.11	10.02
			Peelings, ripe	1.90	7.71	4.34	17.61
			Pulp and juice, unripe	----	----	0.91	9.17
			Peelings, unripe	3.96	15.52	5.37	21.05
26. *Sizygium cumini* (Linn.) Skeels	Duhat	Black plum Java plum	Pulp and skin, ripe	0.20	1.20	0.39	2.34
			Pulp and skin, unripe	0.27	0.97	0.27	0.97
27. *Punica granatum* Linn.	Granada	Pomegranate	Pulp, ripe	1.89	6.76	2.95	10.55
			Seeds, ripe	0.27	1.15	1.89	8.04
			Pulp, ripeun	2.19	6.93	3.08	9.75
			Seeds, unripe	0.79	6.38	1.60	12.92
28. *Anona muricata* Linn.	Guwayabano	Soursop	Pulp, ripe	1.00	6.29	2.14	13.46
			Pulp, unripe	1.06	6.25	1.77	10.44
29. *Fragraria vesea* Linn.	Istroberi	Strawberry	Whole fruit, ripe	0.26	2.46	0.77	7.29
30. *Artocarpus heterophylus* Lam.	Langka	Jackfruit	Pulp, ripe	0.11	0.37	1.14	3.87
			Pulp, unripe	0.30	2.71	0.85	7.68
31. *Lansium domesticum* Correa	Lansones	Lanzon	Pulp, ripe	0.29	1.55	0.73	3.90
			Pulp, unripe	0.86	6.57	1.36	10.39
32. *Eugenia polycephaloides* C.B. Rob.	Lipoti	----	Whole fruit, ripe	0.37	2.05	0.95	5.25
33. *Eriobotrya aponica* Lindle.	Lokwat	----	Without seeds, unripe	0.56	3.08	1.00	5.50
			Pulp, ripe	0.48	3.60	1.15	8.62
			Peelings, ripe	2.77	16.88	4.72	28.76
			Pulp, unripe	1.15	11.30	1.75	19.16
			Peelings, unripe	3.92	19.87	5.31	26.91

TABLE 1.—*Comparative analytical data of some Philippine ripe and unripe fruits.*—Continued.

Scientific name	Local name	English name	Parts used	Calcium Pectate			
				Acid-soluble pectin		Total pectin	
				Fresh basis	Dry basis	Fresh basis	Dry basis
				gm/100 gm	*gm/100 gm*	*gm/100 gm*	*gm/100 gm*
34. *Diospyros discolor* Willd.	Mabolo	Ebony	Pulp, ripe	0.51	2.18	1.40	5.99
			Pulp, unripe	1.66	8.03	1.94	9.38
35. *Syzygium samarangense* (Blume).	Makopa	Curacao apple	Whole fruit, ripe	0.49	4.39	1.06	9.50
			Without seeds, unripe	0.57	5.48	0.95	9.13
36. *Mangifera indica* Linn.	Mangga, kalabaw	Mango	Pulp, ripe	0.32	1.36	1.10	4.68
			Pulp, unripe	0.70	4.45	1.11	7.06
37. *Mangifera indica* Linn.	Mangga, Indiyan	Indian Mango	Pulp, ripe	0.54	2.65	1.51	7.42
			Pulp, unripe	0.62	3.90	0.99	6.23
38. *Mangifera indica* Linn.	Mangga, piko	Mango	Pulp, ripe	0.24	1.43	0.94	5.61
39. *Cucumis melo* Linn.	Milon, kastila	Cantaloupe Spanish melon.	Pulp, unripe	0.93	7.20	1.04	8.05
			Pulp, ripe	0.23	4.88	0.62	13.16
40. *Cucumis melo* Linn.	Milon	Cantaloupe, round smooth, var.	Pulp, unripe	0.39	8.88	0.72	16.40
			Pulp, ripe	0.08	0.95	0.49	5.82
			Pulp, unripe	0.39	4.80	0.67	8.25
41. *Citrullus vulgaris* Schrad.	Pakwan	Water melon	Pulp, ripe	0.10	1.50	0.31	4.65
			Pulp, unripe	0.12	2.51	0.27	5.64
42. *Carica papaya* Linn.	Papaya	Papaw	Pulp, ripe	0.20	2.14	1.95	20.88
			Pulp, unripe	0.67	8.93	3.32	44.26
43. *Passiflora edulis* Sims.	Pasionaria	Passion fruit	Juice, ripe	----	----	0.18	0.90
			Juice, unripe	----	----	0.24	1.45
44. *Canarium ovatum* Engl.	Pili	Pili	Pulp, ripe	0.60	1.87	3.06	9.53
			Pulp, unripe	2.27	8.95	3.34	13.17
45. *Ananas comosus* (Linn.) Merr.	Pinya	Native pineapple	Pulp, ripe	0.24	1.32	0.70	3.84
			Pulp, unripe	0.28	2.17	0.94	7.29
46. *Artocarpus communis* Forst.	Rimas	Breadfruit	Pulp, ripe	0.12	0.40	1.87	6.28
			Pulp, unripe	1.88	6.42	3.96	13.52
47. *Musa sapientum* Linn.	Saguing, bungulan	Banana	Pulp, ripe	0.28	1.06	1.11	4.19
			Pulp, unripe	0.40	1.24	0.88	2.73
48. *Musa errans* (Blanco) Teodoro var. *Botoan* Teodoro.	Saguing, butuan	Banana	Pulp, ripe	0.51	1.88	1.49	5.50
			Pulp, unripe	0.74	1.87	2.03	5.13
49. *Musa sapientum* Linn.	Saguing, gloria	Banana	Pulp, ripe	0.07	0.19	0.49	1.36
			Pulp, unripe	0.14	0.37	0.48	1.28
50. *Musa sapientum* Linn.	Saguing, lakatan	Banana	Pulp, ripe	0.32	1.03	2.08	6.69
			Pulp, unripe	0.54	1.42	1.78	4.67
51. *Musa sapientum* Linn.	Saguing,lantundan	Banana	Pulp, ripe	0.57	1.73	1.05	3.19
			Pulp, unripe	2.42	7.08	2.97	8.69

52. *Musa sapientum* Linn.	Saguing, morado	Banana	Pulp, ripe	0.62	2.06	1.30	4.32
			Pulp, unripe	0.75	1.86	1.42	3.52
53. *Musa sapientum* Linn.	Saguing, saba	Banana	Pulp, ripe	0.48	1.69	1.72	6.04
			Pulp, unripe	0.74	1.73	1.58	3.70
54. *Musa sapientum* Linn.	Saguing, ternate	Banana	Pulp, ripe	0.42	1.14	0.93	2.52
			Pulp, unripe	0.53	1.36	0.95	2.44
55. *Tamarindus indica* Linn.	Sampalok	Tamarind	Pulp, ripe	0.06	0.11	0.06	0.11
			Pulp, unripe	0.31	1.65	0.48	2.56
56. *Sandoricum koetjape* (Burm f.) Merr.	Santol		Pulp, ripe	1.18	7.63	2.63	17.01
			Pulp, unripe	1.29	6.12	2.50	11.87
57. *Flacourtia ramontchi* L'Herit.	Serali	Governor plum	Whole fruit, ripe	0.54	2.42	1.21	5.43
			Whole fruit, unripe	0.94	3.42	1.48	5.38
58. *Spondias purpurea* Linn.	Sineguelas		Pulp and skin, ripe	0.84	4.77	2.52	14.32
			Pulp and skin, unripe	1.18	4.92	2.39	9.97
59. *Spondias cytherea* Son.	Sineguelas amerikano	Otaheite apple	Whole fruit, unripe	0.76	4.98	1.49	9.76
60. *Citrus maxima* (Burm) Merr.	Suha	Pomelo	Pulp and juice, ripe	0.53	5.67	1.23	13.15
			Peelings, ripe	3.20	14.32	5.66	25.33
			Pulp and juice, unripe	0.71	5.53	0.94	7.32
			Peelings, unripe	3.28	13.08	4.42	17.63
61. *Ovaria rufa* Blume	Susong kalabaw		Pulp, ripe	0.62	4.58	1.07	7.90
			Pulp, unripe	1.37	5.49	1.46	5.85
62. *Lucuma nervosa* A. DC.	Tiesa	Canistel	Pulp, ripe	0.93	2.27	1.45	3.54
			Pulp, unripe	0.99	2.47	1.17	2.92
63. *Azhras zapota* Linn.	Tsiko	Sapodilla	Pulp and skin, ripe	0.31	1.09	1.62	5.68
			Pulp and skin, unripe	0.78	2.64	1.50	5.08
64. *Calocarpum sapota* (Jacq.) Merr.	Tsiko mamei	Marmalade plum	Pulp and skin, ripe	0.26	0.78	1.05	3.14
			Pulp and skin, unripe	1.13	2.86	2.78	7.04
65. *Syzydium malaccense* (Linn.) Merr. & Perry.	Yambo	Malay apple	Pulp and skin, ripe	0.42	5.72	1.15	15.67
			Pulp and skin, unripe	0.68	9.44	1.10	15.27

ripe fruits. A transformation of insoluble pectic substances into soluble ones occurs during ripening and in more than half of the analyses, there is a subsequent decrease in total pectic substances on the fresh weight basis.

The peelings of all the citrus fruits analyzed are high in pectin content. The dried peelings of these fruits which are by-products of citrus juice manufacture, are potential sources of citric acid, citrus oil and pectin. Analysis for pectic constituents also reveals that *anonas, guayabano, papaya, pili, bayabas, rimas, santol, sineguelas, biriba* peelings, *kamatis* (pear tomato), *datiles, granada, lokwat* peelings, *saguing* and *tsiko mamei* are rich in pectin.

Results obtained on the analysis of the various ripe and unripe fruits for ascorbic acid content showed no definite trend. Some fruits contain more vitamin C when ripe and others when unripe. Excellent sources of ascorbic acid are *datiles, kamatsili, kasuy, kolobot, granada, mangga indiyan, mangga* (piko var.), *tsiko,* and *suha. Kalamansi* juice contains good amounts of ascorbic acid. The practice of dipping peeled fruits, which are utilized for fruits salad preparation, in dilute *kalamansi* juice helps prevent browning and thus retains the natural color of the peeled fruit.

SUMMARY

Analytical data, with reference to pH, soluble solids, total solids, acidity, ascorbic acid, and the various soluble pectin fractions have been presented for 65 ripe and/or unripe fruits. The pH value of the fruits analyzed ranged from pH 2.0 to 6.8. Most fruits of low pH value showed correspondingly high acidity number. In most cases ripe fruits showed higher soluble solids concentrations, a lower total solids content and a higher water-soluble pectin, than the unripe fruits.

From an examination of the various fruits for Vitamin C, it has been found that *datiles, kamatsili, kasuy, kolobot, granada, mangga indiyan, tsiko,* and *suha* are excellent sources of ascorbic acid.

Analyses for pectic constituents indicates that *citrus* peelings, *anonas, guayabano, papaya, pili, bayabas, rimas, santol, sineguelas, biriba* peelings, *kamatis* (pear tomato), *granada, lokwat* peelings, *saguing* and *tsiko mamei* are rich in pectin.

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THE TERTIARY ALKALOIDS OF MAHONIA PHILIPPINENSIS TAKEDA *

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According to literature on the Berberidaceæ, the *Berberis* and *Mahonia* are so far the only genera within the family which yielded tertiary alkaloids of the bisbenzylisoquinoline series, the most commonly occurring being oxyacanthine (I), berbamine (II), and isotetrandrine (III).

In the Philippines the family is represented by only two known species: *Berberis barandana* Vidal and *Mahonia philippinensis* Takeda. In a previous paper,(1) we have reported *B. barandana* to contain berbamine along with the quaternary alkaloids berberine, jatrorrhizine, and palmatine. Only the quaternary alkaloidal portion of *M. philippinensis* had been investigated by Castro, et al.,(2) who isolated berberine, shobakunine, and jatrorrhizine from the stem. The further alkaloidal investigation of this latter species would afford a comparison of the alkaloidal content of the berberidaceous species of the Philippines and of the other regions.

In this present investigation, the alkaloidal extract of the dried powdered root and stem of *M. philippinensis* was prepared using ethanol as solvent. After separating the quaternary portion, the tertiary portion was separated into the phenolic and nonphenolic fractions, in accordance with the results of the preliminary tests. The nonphenolic fraction yielded colorless prisms, m.p. 179 to 180°, $[\alpha]_D^{31°} + 144°$ (in $CHCl_3$), in 0.0084 per cent yield, which was identified as isotetrandrine by mixed melting point determination, paper chromatography, elementary- and IR-analyses. From the phenolic fraction berbamine was isolated as colorless plates, m.p. 145 to 146° (dec.), in 0.0004 per cent yield, and identified in a similar manner as in the above case.

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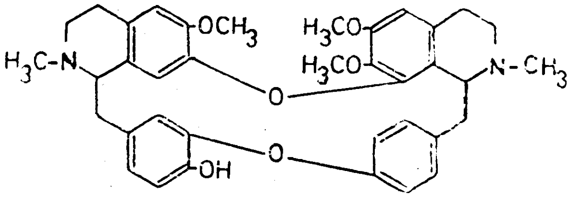
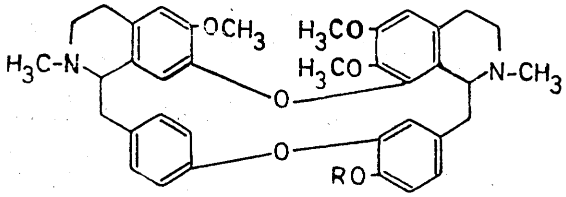


(I) Oxyacanthine



(II) R = H Berbamine
(III) R = CH_3 Isotetrandrine

From a survey of the literature, it is noted that both oxyacanthine and berbamine occur together in the European species of the Berberidaceæ, while the American species contain either one or the other. In the Indian *Berberis* species berbamine in some cases occurs alone, in other instances, together with oxyacanthine, but the latter has not been found to occur alone. The reverse is true in the case of the Indian *Mahonia* species, where in almost all instances only oxyacanthine is present, except in one species where it is found with berbamine. It is also of interest to note that in the Indian Berberidaceæ berbamine is the main tertiary alkaloid in the *Berberis* species and oxyacanthine, in the *Mahonia* species, while in the Japanese Berberidaceæ, berbamine is the most frequently occurring tertiary alkaloid in both genera, although it occurs in smaller yield than oxyacanthine when found together.

v. Bruchhausen, et al.(3) mentioned that O-methylberbamine, which was proven to be isotetrandrine, was obtained by Santos(4) in small quantities from the European *Berberis vulgaris* besides berbamine and oxyacanthine. In the Japanese Berberidaceæ, isotetrandrine was found in *M. japonica* DC. together with berbamine by Tomita and Abe.(5) It also occurs in *B. Thunbergii* DC, which Tomita and Yang(6) found also to contain berbamine and oxyacanthine. This is of interest, since berbamine and isotetrandrine are analogs, and a berbamine-isotetrandrine combination has not been found in the American and Indian Berberidaceæ. Of particular interest is the fact that in all of the Formosan *Berberis* and *Mahonia* species examined, the tertiary alkaloids are of this combination, oxyacanthine being absent.

A comparison of the quaternary alkaloidal content of these species do not offer much significance. Considering the tertiary alkaloidal content, however, it is observed that the two species of the Philippine Berberidaceæ are more closely related to the Formosan and Japanese species, particularly to the former, than to the Indian species, by the absence of oxyacanthine and by the occurrence of berbamine and isotetrandrine together in at least one of them. Considering the geographical relations of the regions concerned, such an observation may be of biogenetic significance.

EXPERIMENTAL

Preparation and treatment of the extract.—From 10.8 kg dried, powdered root and stem of *Mahonia philippinensis* Takeda;[2] the alkaloidal extract was prepared in the Lloyd Extractor using ethanol as solvent. The extract was concentrated to a syrupy residue weighing 490 gm. After separation of the resins by boiling with 1 per cent acetic acid and removal of neutral principles by shaking with ether, the tertiary alkaloidal portion was shaken out from the quaternary portion by ether extraction. The aqueous alkaline quaternary portion was acidified with hydrochloric acid and set aside.

Treatment of the tertiary portion.—A small amount of the ethereal tertiary portion was subjected to preliminary tests (paper chromatography alongside authentic berbamine, oxyacanthine and isotetrandrine; solubility tests), the results of which indicated the presence of phenolic and nonphenolic alkaloids. Accordingly, the main ethereal extract was shaken up with 2 per cent sodium hydroxide solution. The aqueous alkaline fraction, containing the phenolic alkaloid, was acidified with hydrochloric acid and set aside.

[2] The plant materials were collected from the forests adjoining Baguio City.

(*a*) *Isolation and identification of isotetrandrine.*—The ethereal fraction, containing the tertiary nonphenolic alkaloid, was evaporated to dryness, and the residue was purified through the hydrochloride, yielding colorless prisms, m.p. 179 to 180°, from ether. Yield: 0.91 gm (0.0084 per cent). The crystals gave no melting point depression in admixture with authentic isotetrandrine, m.p. 179 to 181°. Paper chromatography showed both substances to have the same R_f value, 0.78. Specific rotation: $[\alpha]_D^{31°}$ $+$ 144° (in $CHCl_3$). IR-Analysis (in $CHCl_3$) made in conjunction with authentic isotetrandrine showed the spectra of both compound to be identical.

$C_{38}H_{42}N_2O_6$ (622.8) Calcd.: C 73.29 H 6.80 N 4.50
Found: 73.41 6.95 4.43

(*b*) *Isolation and identification of berbamine.*—Ether extraction of the aqueous fraction corresponding to the phenolic fraction yielded upon concentration a very small yield of colorless plates, m.p. 145 to 146° (dec.). Yield: 37.8 mg (0.0004 per cent). A mixed melting point determination with authentic berbamine, m.p. 150° (dec.), did not show any depression. Paper chromatography alongside authentic berbamine indicated both substances to be identical. IR-Analysis (in $CHCl_3$) was made, and the spectrum obtained was identical to that of authentic berbamine.

All melting points are uncorrected, and were determined using the Hilbck hot-stage melting point apparatus. Optical rotation determination was made using a Hilger Standard Polarimeter. Paper chromatography was carried out by the ascending method on Whatman No. 1 paper impregnated with n-butanol in a solvent system composed of 10 per cent sodium sulfate solution and 0.1 N hydrochloric acid solution (1:1 ratio), and the chromatograms were printed by wetting with modified Dragendorff reagent. The IR-spectra were taken on a Perkin–Elmer Infracord Spectrophotometer, Model 137B, using sodium chloride prisms.

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THE LICHEN GENUS USNEA AND ITS SPECIES AT PRESENT KNOWN FROM THE PHILIPPINES

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INTRODUCTION

This paper treats of those lichens belonging to the genus *Usnea* that are thus far known from the Philippines. It is hoped that more attention will be paid to the ornamental but sadly neglected plants so lavishly displayed in our primitive forests. In view of the rapid depletion of our forests, especially since World War I, it is urged that Usneas be collected before most of them disappear.

The genus *Usnea* includes lichens of two general patterns of growth. In one type the plants are more or less elongate, sometimes excessively so, attaining a length of several meters; naturally they are pendulous with branches varying from those more or less hairlike to others with very coarse branches which may be like rods or sticks with all gradations between these two extremes. In the other type of growth the plants are more or less erect and more or less bushy in habit. There is every possible variation between the extremely elongate to those of short broad shrubby or bushy habit.

Usneas usually occur on the trunks, branches, and twigs of trees and shrubs, both living and dead. They may also occur on old fences, boards, shingles, and on rocks.

They are commonly known as "beard moss" and "old man's beard" in many languages and occur all over the world wherever a suitable habitat occurs. They are found from sea level to the timber line, and beyond that on lofty mountains. They are the plants referred to by Longfellow in the opening lines of Evangeline:

> This is the forest primeval, the murmuring pines and the hemlocks
> Bearded with moss and gray and in garments green, indistinct in the twilight,
> Stand like Druids of eld with voices sad and prophetic,
> Stand like harpers hoar, with beards that rest on their bosoms.

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The color of an *Usnea* is an important character. The commonest color is a gray green but this varies in different species from almost white through all the shades of greenish and yellowish to bright straw color and various shades of yellow to orange, while some kinds are reddish to clear red, rust color or brick red. In other species every variation is found from clear pale green to brilliant emarald and on through olive to almost blackish green and sulfur green. In some from subpolar regions purplish violet and black also occur. These colors are all in living plants. Herbarium specimens may, after the lapse of many years, become tan, brown to dusky or some shade of red, though in life they may be clear green.

No plants are more sensitive to climatic conditions than Usneas. None are more responsive to slight variations in temperature, rainfall, sunshine, air pollution, and other factors which go to form the weather. A complete exhibit of the Usneas of a given geographic area would give a key to the climate of the region. Over a century ago lichenologists pointed out that most lichens disappeared in cities, and that their abundance testified to the purity of the atmosphere.

In 1936–1938 Dr. Jozef Motyka, a Polish plant geographer, after many years of research, published his monumental Monograph on the Usneas of the world. He introduced new methods and brought new concepts to the study of these neglected plants. In 1956 Dr. Y. Asahina published the results of his exhaustive studies of Japanese Usneas, following in the main the methods of Motyka. In this paper I am following both Motyka and Asahina, with some modifications based on my studies of North American, Philippine, and East Indian Usneas.

The parts of an individual plant of the genus *Usnea* are the base or holdfast, the stem (either or both of these may be absent), the primary branch or branches, the secondary branches, and the branchlets or fibrils; to these Motyka adds the extremities or tips of the branches. Usneas may also have apothecia or fruiting bodies, or they have soredia very few kinds have both apothecia and soredia.

The holdfast, when present, is defined by its name and fastens the plant to the substratum. The most usual cause for its absence is carelessness on the part of the collector. The place where the *Usnea* begins growth is the primary base. It may be of uniform thickness, or more or less attenuate, or again it may be thickened and dilated or disklike at the place of attachment and is then said to be "gomphate." In some species the tips of branches coming in contact with the substratum may develop secondary holdfasts. Besides forming an additional support, the new holdfast may become the center for another plant. In this way two, three, or more plants may all be connected by stout vigorous anastomosing branches, just as some flowering plants send out runners which strike root and start new plants with mother and daughters all connected. The holdfast is often darker than the rest of the *Usnea,* and one may see them all the shades from concolorous to black.

The basal part of the stem rises directly from the holdfast and sooner or later divides into the primary branches. The main stem may be elongate or may be very short or even nonexistent, as where several stems grow directly from the base. In some species the primary branches are more or less dusky to black.

Three main ways of branching are readily observed. In filamentous species such as *Usnea longissima* or *Usnea squarrosa* var. *misamisensis,* the short main stem divides dichotomously into more or less equal primary branches. These in turn by dichotomy form elangate secondary branches which are more or less parallel and are more or less thickly covered with branchlets or fibrils growing out at right angles to the secondary branches.

In the excurrent mode of branching, sympodial or subsympodial, the main stem or sympodium runs through to the tip. When it divides one branch becomes much larger and stronger than the other, so that the main stem has a sinuous or irregular course, as in *Usnea erecta* and some other shrubby species.

In the deliquescent type of branching the main stem is seen only in the lower part of the thallus. By repeated branching, more or less dichotomous and again sympodially the main stem becomes lost in the upper part of the thallus, as in *Usnea rubicunda.*

Many kinds of Usneas have terete branches, that is perfectly circular, but some are more or less deformed and some (Though not in the Philippines) are strongly angulate. The surface is seldom perfectly smooth although some species are not only very smooth but may be shiny, as if varnished and polished. The surface is made uneven by papillæ, cilia or minute hairlike fibrils, tubercles, warts, folds or wrinkles, and pits, while some lichens have a scurfy surface, as in *Usnea squarrosa.* The surface is called foveate when the pits are very small and scrobiculate when the depressions are larger. Some kinds also have the surface more or less cracked or broken, causing the branches to be more or less jointed or articulate. In extreme cases the joints may be almost beadlike. In some Usneas with prominent articulations the medulla forms prominent white margins of regenerative tissue at the ends of the joints. Then are them called limbiform, from the Latin *limbus,* a border.

Papillæ are very short tubular or globose projections or growths from the surface, with rounded or pointed tips. They have no opening at the tip. They are usually concolorous but may be of various colors, reddish or dark or even black. Papillæ may be few and scattered or may be as close together as they can stand. They may be confined to certain parts or may be well distributed over primary and secondary branches. Cilia are hairlike and longer than papillæ. Warts or verrucæ are like minute angular pimples on the surface of branches. They burst open at the top and give off soredia. Tubercles are larger growths on the surface, of irregular size and shape, the result of some break in the cortex.

The *Usnea* thallus is made up of the cortex or outer rind, the medulla, and the axis. The cortex is composed of radial fungal hyphæ firmly fastened together. It may be of uniform thickness or very irregular and extending here and there into the medulla, from which it may be very sharply or again indistinctly separated. The cortex may range from comparatively soft tissues to very hard, and from brittle to very tough.

The space between the cortex and axis is filled with the medulla which may be of densely to very loosely woven hyphæ. A broad medulla with very lax or cobwebby hyphæ is called arachnoid. When very narrow the medulla is always dense. The algæ upon which the life of the *Usnea* depend form a zone in the outer part of the medulla. The color of the medulla is nearly always white but may vary to pink, rose-red, through various shades of red to brick-red. A Hawaiian species has a violet medulla. The algæ are nearly always of the Protococcus group, but in one section they are Trentepohlia.

The axis is a strong central cord running lengthwise through the *Usnea* thallus. It is made up of hydæ glued together to form a longitudinal tapering bundle, and is usually circular in section but may be flattened, irregular, or effigurate. In the subgenus *Eumitria* there is a large distinct cavity in the axis, at least in the larger branches if not in all of them. In the rest of the Usneas the axis is nearly always completely solid, but in a few species it may have crevices or fissures. The axis may vary from moderately firm to cartilaginous or horny and very hard. The axis is pale, whitish in most species, but sometimes is yellowish. Now and then one finds an *Usnea* with a reddish or red axis; this is not a normal condition but is the result of decay or disease. In a number of species the axis is more or less speckled or blotched by dark specks or larger blotches when seen in cross section. These are due to dead or diseased hyphæ and are a characteristic feature of certain species. This character shows best in the larger branches but may be either present or absent in the smaller branches.

As a rule the cortex is thinner than the medulla, and this in turn is usually less than the axis. In some Usneas the medulla and axis are about equal in thickness and in a number of species the diameter of the axis is notably less than the width of the medulla. In a very few species the cortex is as wide than the width of the medulla. In a very few species the cortex is as wide as the medulla or even wider.

When the determination of an *Usnea* is at all doubtful one should make sections of the thallus and measure cortex, medulla, and axis. An *Usnea* in which the medulla is far greater than the axis cannot be the same as one in which the axis diameter far exceeds the width of the medulla. Also an *Usnea* with a cortex wider than the medulla must be different from one with a thin papery cortex only a fourth of the medulla in thickness. In studying the anatomy of an *Usnea* one should take sections from a branch above the middle of the thallus.

METHODS OF REPRODUCTION

Some species of *Usnea* always bear apothecia or fruiting bodies, as *Usnea erecta*. A large number of species often have apothecia while others have them but rarely, as *Usnea eumitrioides* and *Usnea schadenbergiana*. This leaves many which are always sterile.

The apothecia are really borne laterally on the branches but often seem terminal because the branch beyond the attachment of an apothecium becomes atrophied. The internal structure of the apothecia and the size and shape of the spores are so uniform that they are of no help in determining species. The things to be noted about apothecia are their size, shape, color of the disk, character of the marginal fibrils, and the nature of the back or excipulum. This may be smooth, wrinkled, reticulate, more or less papillate, or more or less densely clothed with fibrils.

Sterile species of *Usnea* are usually reproduced by soredia. Each minute soredium is a tangle of hyphæ enclosing algæ, and may give rise to a new plant if it lights on a favorable spot. Soredia are of two types, insidiose and farinose. Isidia are like minute spines, from less than 0.5 to 1 mm in length; they are constricted basally and are detached with great ease. Farinose soredia are minutely granulose, or like the finest flour or powder. Soredia may originate singly upon tubercles or slight depressions in the cortex. Usually they are produced in quantity in nests or breaks in the cortex called soralia. Isidiose soralia may be broad or pointed and produce isidia on the tips of tubercles. Farinose soralia may erode the thallus in craterlike pits, or in other species they may become elevated and eventually globose or capitate.

Soredia are usually produced on the smaller branches and branchlets, less often in the central part of the thallus and rarely on the thicker branches. They are given off in vast number and are widely distributed by wind and water. As a rule an *Usnea* with apothecia does not bear soredia, and *vice versa*. However some species may bear both at the same time, but this is not true of any Philippine species, so far as is known.

The kind of soredia, whether farinose or isidiose, is very important in the determination of species. In some species the soredia begin as isidia but with age become farinose. Then one has to find young soredia to fix the status of the specimen. In the herbarium soredia often become farinose, eroded, and finally lost so that identification may become very difficult.

There is still another mode of reproduction and distribution of prime importance in some species, such as *Usnea longissima* and *Usnea squarrosa* and its variety *misamisensis*. It is that of fragmentation or the breaking off of pieces of the thallus which are then blown about by the wind. These fragments may be large tangled masses or only a few strands or branches, but for the most part they are only filaments, which may be very short or quite elongate threads. *Usnea longissima,* a circumpolar lichen has no soredia and bears apothecia but rarely, and is propagated by fragmentation throughout most of its range. Myriads of fibrils, filaments, and branchlets are wind borne in almost incredible numbers, and thus distributed over great areas.

In determining an *Usnea* it is often necessary to examine its internal anatomy. After carefully noting all its external features. To do this take a razor or scalpel and remove a piece of the cortex, thus exposing the medulla and axis. After noting respective charatcers, one should apply a drop of potassium hydroxide solution, known as KOH or simply as K, and observe the reaction, or lack of it, on the medulla.

By making a cross section of a branch and examining it under the microscope one not only sees the features of the cortex, medulla, and axis, but notes their measurements in microns. This is a matter of prime importance. It has already been stated that these vary greatly, and to equalize these differences one should examine several sections in the following manner: Take the thickness of each part on two diameters crossing at right angles. Then take the mean average of the four cortex measurements, the four of the medulla, and the two of the axis. By doing this for several sections one will get the mean average thickness of the three components.

Botanists and nature lovers should collect Usneas. No other plants are more responsive to ecological conditions. When you collect an *Usnea* be sure you take the whole plant, including the holdfast. It is probable that as yet we do not know more than two-thirds of the Usneas adorning Philippine forests. Usneas known from Formosa, Borneo, Celebes, Thailand, Malaya, and elsewhere in southeastern Asia and the island world adjacent may well occur in the mountains of Luzon, Mindanao, Negros, Leyte, etc. Not a single *Usnea* has ever been collected from the high mountains of Palawan.

Usneas are very easily preserved. Simply arrange them between sheets of newspaper or regular botanical paper and apply light pressure for a day or two, as they dry quickly. After drying they should not be glued to herbarium sheets. Instead they should be kept in packets or envelopes of suitable size, regulated by the size of the specimens.

In studying Usneas one must remember that they are plastic organisms and therefore highly variable, and that it is folly to expect all the members of a given species to be exactly alike. People are prone to look upon specimens which differ slightly in some respect to be a different kind or even a new species. Carried to extremes, as is done by some, a species becomes nearly the specimen in hand. This, of course, is very far from being the case. A species is a certain population of plants or animals which has certain distinctive and unifying characters and which occupies a definite ecological niche in the living world. This does not mean that each individual of a species must agree in every external morphological character visible to the eye, as well as in all microscopic details and chemical reactions. Every experienced student of comparative anatomy of either plants or animals soon learns that most organisms are subject to great individual variations.

This innate variability is as much a part of life and heredity as is likeness, and must always be considered in judging the limits of a given species. Of course some kinds of *Usnea* are more fixed while others are more markedly variable, and this must be remembered in determining them. It is therefore important to examine large series of specimens from as many widely separated localities as possible. When one is able to do that he often finds that some apparently different Usneas are connected by gradations which show them to be in reality a single species.

REAGENTS USED ON USNEAS

K or KOH, composed of equal weights of caustic potash and water; I or Iodine, use Lugol solution or the following: Iodine, 1 grain; potassium iodide, 3 grains; and distilled water, one-half ounce.

Artificial Key to the Usneas at present known from the Philippines, by Albert W. C. T. Herre, Stanford University (emeritus).

A. Axis hollow, at least in the thicker branches, the cavity empty or more or less filled with cobwebby hyphæ .... Subgenus *Eumitria*
  B. Thallus pale ashy yellow straw color; medulla very thin, less than cortex, with pale lemon yellow arachnoid hyphæ; axis about 0.8 of branch, its wide cavity filled with arachnoid hyphæ.... *chrysopoda*
  BB. Thallus pale ashy green or whitish green; soredia isidiose, rather long, abundant, concolorous; apothecia rare.
    C. Plants usually about 70 mm but up to 130 mm, dichotomously branched, branches usually serpentine flexuous, up to 2 mm

thick, covered with isidiose soredia; cortex thin, about 40; medulla dense, about 90 μ, yellow with K; axis about 500 μ, cavity about 230 μ .... *insignis*

CC. Thallus larger, ashy green, often seemingly pruinose; medulla roseate.

D. Thallus about 200 mm long, very strong, up to 2 mm thick, branchlets over whole length; axis 0.8 of branch, with wide cavity; medulla light yellow with K .... *baileyi*

DD. Thallus 7 to 150 mm, thin, branchlets rather dense on lower part; medulla very dense; axis about 0.9 of branch, horny, cavity about ⅔ of axis, filled with separate hyphæ. *implicita*

AA. Axis solid, or sometimes more or less torn, never with a distinct well defined cavity; thallus never black or sulfur colored with blackened tips; highly variable, from short, shrubby or tufted to pendulous and long to very elongate; sometimes little branched or now very much branched; apothecia when present pale, often pruinose, rarely dark, never black .... Subgenus *Euusnea*

E. Thallus distinctly red or red spotted in life, due to red coloring matter in the cortex.

F. Thallus some shade of clear bright red to dark red; 50 to 70 mm in length, rarely more; medulla yellow with K .... *rubicunda*

FF. Thallus usually about 150 mm but becoming twice that length, pendulous, rust red to brick red, or sometimes paler or spotted with gray; medulla passing from yellow to red with K *rubescens*

EE. Thallus not red or red spotted in life but always some shade of green.

G. Medulla roseate, or violet rose, dense, yellowish with K; thallus about 50 mm long, pale pure green .... *roseola*

GG. Medulla not roseate.

H. Thallus articulate, soft, limp, usually pale straw color; cortex sprinkled with tiny irregular white linear pseudocyphellæ; medulla about twice the axis, exceedingly lax, turning yellow, then dark red with K .... *flexilis*

HH. Thallus without pseudocyphellæ.

I. Axis blue with I.

J. Thallus with little or no cortex except on branchlets; medulla reduced to minute farinose or tartareous clumps; thallus thin, pendulous, a meter to several meters in length; axis at once deep blue with I; branchlets numerous, characteristic, at right angles to branch. *longissima*

JJ. Thallus with cortex; medulla well developed; thallus 200 to 600 mm in length.

K. Thallus up to 300 mm, freely and irregularly broken into areoles, wide shallow fissures filled with regenerative tissue; medula deep red to blackish red with K; axis very hard, deep violet blue with I. *squarrosa*

K var. Thallus up to 600 mm; medulla more or less yellow with K; axis with dusky hyphæ interspersed. var. *misamisensis*

KK. Thallus not areolate with conspicuous regenerative tissue in fissures between areoles.

L. Branchlets numerous, 10 to 40 mm long; medulla yellow with K.

M. Thallus up to 400 mm; branchlets short, rarely over 10 mm long, thick, curved; cortex very thin, 20 μ; medulla circa 100 μ, dense, yellow or orange with K; axis circa 360 μ, violet or blue with I, reaction sometimes lacking .... *hossei*

MM.* Branchlets stiff, 20 to 40 mm long, annulate; cortex 60 μ thick; medulla 100 to 150 μ, yellow to dark yellow with K; axis 600 to 1,150 μ, with bunches of darker hyphæ and a central cavity filled with lax hyphæ; axis more or less light blue with I; thallus up to half a meter. *schadenbergiana*

LL. No branchlets.

N. Medulla less than axis; about 180 μ, very dense, red with K; thallus annulate, but also obliquely and irregularly fractured; axis about 250 μ in diameter .... *mearnsi*

NN. Thallus 300 mm or more; cortex circa 100 μ medulla 600 μ, very dense, K-; axis about half as wide as medulla, with bundles of darkened hyphæ, deep blue with I .... *philippina*

II. Axis not blue with I.

O. Branchlets none.

P. Medulla rather dense.

Q. Thallus about 250 mm long, opaque; primary branches articulate, up to 1.8 mm thick, tips hairlike; cortex about 110 μ; medulla 300 μ, yellow with K; axis about 250 μ. *marivelensis*

QQ. Thallus shiny, about 550 mm long; primary branches up to 1 mm thick; cortex very hard, about 50 μ thick; medulla about 230 μ, yellow with K, then red; axis absent 400 μ. *montagnei*

PP. Medulla very lax and more than axis.

R. Thallus very small, 18 to 35 mm high dichotomously branched; soredia abundant, large, farinose with large granules; cortex about 50 μ thick; medulla about 200 μ, very lax with almost no hypæ, K-; axis about 130 μ in diameter .... *pycnoclada*

RR. Thallus 30 to 40 mm long, sympodially divergently branches, the base and primary branches blackened; cortex 90 to 100 μ wide; medulla 345 to 360 μ, K-; axis 230 to 240 μ in diameter .... *elmeri*

OO. Branchlets numerous.

S. Medulla very lax or arachnoid, thicker than axis.
  T. Thallus 40 to 60 mm long and as wide or wider, base very short black, gomphate; primary branches 1 to more than 2 mm thick basally; cortex 75 μ thick; medulla 320 to 485 μ, yellow then red with K; axis 210 μ, solid .... *humilis*
  TT. Thallus about 130 mm long or more and 90 mm wide, base short, black; several primary branches rise from base, branching dichotomously and sympodially; branches jointed basally and more or less articulate, smooth, more or less shiny; cortex 75 to 85 μ thick; medulla about 450 μ, K-; axis 255 to 270 μ in diameter. *ramosi*
SS. Medulla dense, or dense within, only the outer part lax.
  U. Medulla more than axis; apothecia abundant, terminal; 7 to 10 mm broad; medulla dense within, outer part lax, about 250 μ thick, yellow with K, then dark red to nearly black; axis about 200 μ in diameter; cortex about 100 μ thick; thallus about 800 mm high .... *erecta*
  UU. Medulla less than axis.
    V. Thallus small, 40 to 60 mm long, width equals or is more than height; cortex 70 to 90 μ; medulla dense, yellow then red with K, 160 to 190 μ thick; axis 390 to 405 μ in diameter with few to many darkened hyphæ, these yellow, then red with K. *eumitrioides*
    VV. Thallus about 210 mm long, pendulous, base not black; cortex 35 to 50 μ thick; medulla about 225 μ, bright yellow then red to very dark red next axis, which is 270 to 280 μ in diameter. *laevata*

USNEA CHRYSOPODA Stein.

Usnea crysopoda STEIN, Verh. Schles. Gesells. für Vaterl. Kultur (1882) 4; MOTYKA, Usnea Monogr. (1936–38) 53–54; A. ZAHLBR., Catal. Lich. 10 (1940) 576.

Usnea barbata var. *xanthopoga* MULL.-ARG., Flora 72 (1889) 143.

Eumitria endorhodina VAINIO, Philip. Jour. Sci. § C 4 (1909) 651, Ann. Soc. Zool.-Bot. Fenn. 1 (1921) 34.

Usnea endorhodina A. ZAHLBR., Catal. Lich. 6 (1930) 564.

Thallus about 150 mm long, pendulous, fruticose, rather freely subsympodially and divergently branched, and densely ciliate, stiff, pale ashy yellowish straw color, stiff, smooth, almost shiny. Base short, stiff, thick, dusky, soon branched. Branches about 1 mm thick basally, perceptibly attenuate above, flexuous, continuous or infrequently simply cracked, terete, sprinkled with minute white pointed papillæ. Branchlets rather numerous, 5 to 10 mm long, erect, gracefully flexuous, with rather thick base, the tips thinner, smooth or often tuberculate, pointed. Tips indistinct.

Apothecia not seen. Soredia growing on tubercles but lost in herbarium specimens.

Cortex thin, pale about 80 μ thick. Medulla very thin, about 50 μ thick, pale lemon yellow, K-. Axis very thick, about 80 per cent of the diameter of a branch, horny white, the cavity very wide, filled with lax arachnoid hyphæ.

In addition to the type collection, the Philippine National Museum has a specimen collected by A.D.E.Elmer on the summit of Mt. Pinatubo, Pampanga Province, May, 1927. It was mixed in with *Usnea elmeri.*

No other *Usnea* of the *Eumitria* section has a lemon yellow medulla or a yellow straw colored thallus.

No specimen of Vainio's *Eumitria endorhodina,* collected by Maj. E.A.Mearns on the summit of Mt. Pauai, Benguet, Mountain Province, Luzon, has been located and Motyka says it was not found in Vainio's herbarium. I follow Motyka in making it a synonym of *U. chrysopoda,* though Vainio says it has a roseate medulla instead of the lemon yellow one of *U. chrysopoda.*

Type locality: Mt. Apo, at about 2,000 meters, Davao Province, Mindanao; collected by Dr. Schadenberg, 1882.

Type in the Botanical Museum, University of Breslau.

USNEA INSIGNIS Motyka.

Usnea insignis MOTYKA, Usnea Monogr. (1936–38) 66–67; A. ZAHLBRUCKNER, Catal. Lich. 10 (1940) 590.

Thallus usually about 70 mm long but up to 130 mm, suberect, rather freely dichotomously branched, almost lacking branchlets, densely isidiose sorediose throughout its length and plainly scurfy, uniformly pale ashy green, opaque. Base indistinct, narrowly dusky. Branches not rarely dichotomously branched, nearly always serpentine flexuous, their tips frequently more or less nodding; base about 1.5 mm, the middle of the branches up to 2 mm thick, the tips tapering, but nearly 1 mm thick, terete, little compressed below branchings, continuous or rarely with constricted joints, below naked and nearly smooth, the upper part with minute tubercles, densely covered with soredia. Lateral branchlets very few, like branches, blunt. Tips thick, very blunt, sorediose up to the ends.

Apothecia unknown. Soredia isidiose, very dense and nearly covering the upper part of the branches, concolorous, rather long, in clusters.

Cortex very thin, about 40 μ thick. Medulla dense, about 90 μ thick, roseate, yellow with K. Axis about 500 μ, cavity about 230 μ, white, horny.

Species notable for the branches thick to their usually nodding tips, very blunt, up to the thickly servediose tips.

Collected by E. D. Merrill at Todaye, Mountain Province, Luzon, mixed with other Usneas in No. 1254, Kryptog. Exsiccat., Museum Vindobonensis. Also collected on Mt. Katanglad, Bukidnon Province, February 9, 1949, by M.D. Sulit, at 1,800 meters. Motyka had specimens from Bali and Java.

Type locality: Bali, near Gidgid, on trees; collected by Zollinger, 1856.

Type in National Museum, Budapest, Hungary.

USNEA BAILEYI (Stirton) A. Zahlbr.

Usnea baileyi A. ZAHLBR., Denkschr. Math.-Naturw. Classe Kais. Akad. Wiss., Wien **83** (1909) 182, Catal. Lick. Univ. **6** (1930) 542; MOTYKA, Usnea Monogr. (1936–38) 63–64; A. ZAHLBR., Catal. Lich. **10** (1940) 573.

Eumitria baileyi STIRTON, Scott. Natural. **6** (1881) 100; SHIRLEY, Proc. Roy. Soc. Queensl. **5** (1888) 104.

Usnea barbara var. *asperrima* MULL.-ARG., Flora **65** (1882) 299; SHIRLEY with BAILEY, Queensl. Depart. Agric. Bull., No. **9** (1891) 21.

Usnea percava f. *asperrima* STEINER, Verhandl. Zool.-Bot. Gesells. Wien **53** (1903) 231.

Eumitria asperrima VAINIO, Ann. Acad. Sci. Fenn., Ser. A **6** (1915) 10.

Thallus large, about 200 mm long or more, very strong, sparingly branched, more or less abundantly sprinkled with branchlets, sorediose, uniformly opaque ashy green. Base indistinct. Primary branches usually distinct, very strong, up to 2 mm thick, rather rarely subdichotomously branched, the secondary branches divergent, thin, sparingly branched again. All branches continuous, terete, with large tuberculate papillæ, the tubercles usually slightly oblong, blunt, sorediose, white. Lateral branchlets rather frequent, nearly perpendicular, usually about 5 mm but also up to 50 mm long, flexuous, with wedge-shaped base, attenuate above, rather blunt, nearly always tuberculate sorediose. Tips branched up to their ends.

Apothecia unknown. Soredia isidiose, greenish white, growing in soralia, especially on the branchlets.

Cortex thin, about 60 μ thick, soft. Medulla, thin, dense, roseate, light yellow with K. Axis very thick, occupying 80 per cent of the branch, slightly dusky, the cavity rather wide.

The only Philippine specimens known were collected by E. D. Merrill at Todaye, Mountain Province, Luzon. They were mixed with other Usneas distributed in the Kryptog. Exsicc. Mus. Vindobonensis, No. 1254 B, the principal species in the lot being *Usnea squarrosa.* In addition to Philippine material, Motyka examined specimens from Java, Australia, Tahiti, Madagascar, and East Africa. A widely distributed species but little collected. I have no doubt it occurs on high mountains all over the Philippines, but has been overlooked by collectors.

Type locality: Brisbane, Queensland, Australia; coll. Bailey.

Type in the British Museum Natural History, London.

USNEA IMPLICITA (Stirton) A. Zahlbr.

Usnea implicita A. ZAHLBR., Cat. Lich. 6 (1930) 582 (misprinted as *Usnea implicata*); MOTYKA, Usnea Monogr. (1936–1938) 60–62; A. ZAHLBR., Cat. Lich. 10 (1940) 590; ASAHINA, Lich. Japan, Genus Usnea 3 (1956) 39–41, *text figure 30, Plate 1, fig. 1.*

Eumitria implicita STIRTON, Scott. Natur. 6 (1881) 100.

Eumitria endochroa VAINIO, Philip. Jour. Sci. § C 4 (1909) 651.

Eumitria endochroa var. *farinosa* VAINIO, Philip. Jour. Sci. § C 4 (1909) 652.

Eumitria endochroa var. *papillata* VAINIO, Philip. Jour. Sci. § C 4 (1909) 651. Also Annal. Soc. Zool.-Bot. Fenn. 1 (1921) 34.

Usnea baileyi var. *endorosea* A. ZAHLBR in Scheda Lich. Bariores, No. 255.

Usnea dasypogoides var. *substrigosa* MULL.-AGR., Flora 66 (1883) 20.

Usnea barbata var. *substrigosa* MULL-ARG., Flora 72 (1889) 143.

Usnea dasypoga var. *substrigosa* A. ZAHLBR., Cat. Lich. 6 (1930) 562.

Thallus of medium size, usually 70 to 100 mm long but reaching 150 mm, erect or somewhat pendulous, thick, bushy but loosely branched, sorediate, always sterile, ashen whitish green in life but becoming dusky brown in old herbarium specimens. Thallus base short, up to 1.5 mm in diameter, not attenuate. Primary branches at first almost simple, ready sparingly branched, without numerous branches above. Branches all rather uniform, thickest at the base or only slightly thickened above the base, about 1.3 to 1.5 mm in diameter but reaching 2.0 mm, regularly attenuate throughout, usually slightly flexuous but close together, continuous and only broken into partial rings basally, terete, smooth, almost polished but dull, without papillæ but with many almost subglobose, very blunt, usually farinose warts.

Branchlets rather abundant, 5 to 40 mm long, erect, usually serpentine flexuous, thin, perceptibly attenuate throughout, the upper part paler, almost straw color, slightly sorediose tuberculate to the elongate tips; these virgate, like antennæ.

Apothecia unknown. Soredia isidiose, rather long, thin, on tubercles over most of the branches; these break down to crateriform farinose warts densely covering the branches.

Cortex 30 to 60 μ thick, dusky. Medulla 50 to 70 μ thick, very dense, the inner part roseate; K-. Axis exceedingly thick, 300 to 1,200 μ or 70 to 90 per cent of a branch diameter, horny, white to nearly transparent, the cavity very wide, 50 to 70 per cent of the axis diameter. Motyka gives the medulla as white but it is plainly roseate in authentic specimens.

I have examined specimens collected by M. Ramos on Mt. Arayat, Pampanga Province in February, 1915; and from the summit of Mt. Banahao, Quezon Province (Tayabas), at 7,500 feet, collected by Frank C. Gates and F. Amos, October 18, 1913. Motyka examined specimens from Mt. Polis, Ifugao Subprovince; Vigan, collected by Schadenberg; Todaye, Mountain Province, collected by E. D. Merrill; and from Mt. Banahao, Laguna Province, collected by Merritt and Curran. All Philippine specimens thus far collected have been from Luzon.

This is a very widely distributed *Usnea*. It occurs from Japan to New Zealand, and from Japan to India and the isles of the Indian Ocean, over tropical and South Africa, and from England to Saint Helena; in America it is found from Florida and Louisiana to Mexico, Central America, and the West Indies to Brasil, and occurs also in the Hawaiian Islands. I collected it in Celebes and have examined specimens from Japan, Formosa, the Hawaiian Islands, and the United States.

Type locality: Madeira Island.
Type in British Museum, London.

USNEA RUBICUNDA Stirton.

Usnea rubicunda STIRTON, Scott. Natur. 6 (1881) 102; MOTYKA, Usnea Monogr. (1936–38) 339–345; ASAHINA, Jour. Jap. Bot. 28 (1953) 227; ASAHINA, Lich. Japan, Genus Usnea 3 (1956) 115–117, *fig. 50, Plate 20, fig. 1.*

Thallus commonly 50 to 70 mm in length, and not rarely 100 mm long, seldom more. The largest North American specimen collected at Baguio by R. S. Willams in 1904 has the astonishing length of 220 mm, the primary branches with a thickness of 1.9 mm. Thallus fruticose or cæspitose, more or less erect to prostrate, growing on trees, shrubs, sometimes on rocks, and typically clear bright red to dark rusty or brick red, but quite variable in color; sometimes greenish or glaucous straw color, spotted or variegated with red; occasionally only the tips show red but usually it is clear pure red all over. It is never the kind of red that many species of *Usnea* become after several decades in the herbarium.

Base short, stiff, thick, blackish, the stem freely branched more or less dichotomously and sympodially. Branches upright, divergent, nearly uniform below and usually about 1 to 1.5 mm in diameter, becoming paler and attenuate above; cortex continuous or irregularly broken, the wide cracks showing the white medulla. Branches terete, sprinkled with warts and low tubercles which become farinose sorediate. Branchlets few, small, only on the lower part of the larger branches. This slender, elongate, indistinct.

Apothecia very rare, 2 to 4 and up to 10 mm in diameter; only two fruiting specimens seen from North America; none from the Philippines, Formosa, or Japan. Marginal fibrils numerous on larger apothecia, very few on small ones. Disk nearly flat, more or less flesh color. Small spinelike white isidia nearly always present. On the Philippine specimen already mentioned the isidia are elongate, in nests, and conspicuous; sooner or later the soralia on warts and tubercles become farinose and relatively few isidia are left unchanged.

Cortex thick, cartilaginous, more or less red, the color conspicuous in sections, 75 to 140 μ thick in my section, the inner margin irregular and projecting more or less into the medulla. The dense white medulla becomes yellow with K, 75 to 225 μ in thickness. Axis quite variable, 200 to 440 μ in diameter, irregular or deformed, rarely circular, spotted with darker hyphæ and sometimes with fissures. All the tissues in this *Usnea* vary widely. Motyka gives the cortex *circa* 180 μ; medulla 150 μ; axis 350 μ. Asahina's figures are cortex 50 to 150 μ; medulla 120 to 280 μ; axis 200 to 550 μ.

The only specimen of the typical form of *U. rubicunda* thus far seen from the Philippines is the one already mentioned from Baguio. I have no doubt it is found on high mountains all over the Philippines but has been overlooked by collectors.

Usnea rubicunda is the most widely distributed of all species of *Usnea,* growing on a great variety of trees and shrubs, as well as on rocks. In Asia it occurs in the Philippines, Formosa, Korea, China, Annam, and India. It is known from at least fourteen European countries, from Madeira and the Azore Islands in the Atlantic, and the Hawaiian Islands in the Pacific.

It also occurs over most of North, Central, and South America and in the West Indies.

Motyka recognizes three varieties besides the typical form of *Usnea rubicunda*. One of these occurs in northern Luzon.

USNEA RUBICUNDA Stirton var. ROSEA Motyka.

Usnea rubicunda var. *rosea* MOTYKA, Usnea Monogr. (1936–38) 344–345.

Thallus cæspitose, usually about 50 mm long, branching dichotomously up to the tips; branches about 1.5 mm thick, indistinctly tuberculate to nearly smooth; branchlets almost entirely lacking.

The only Philippine material was collected by me from a tree beside the trial between Bañgad and Lubuagan, Kalinga, Mountain Province, Luzon, May 6, 1923, at an altitude of about 900 meters. This variety was originally described from France and has been collected in Java. No doubt it occurs generally throughout northern Luzon.

The huge specimen of *Usnea rubicunda* collected at Baguio by R. S. Williams was loaned to me by the New York Botanical Garden. I feel under great obligations to that institution for making it possible to study their Philippine Usneas.

USNEA RUBESCENS Stirton.

Usnea rubescens STIRTON, Scott. Natur. 7 (1883) 76; STIRTON, Trans. Proc. New Zealand Inst. 30 (1897–98) 390; MOTYKA, Usnea Monogr. (1936–38) 346–349; ASAHINA, Jour. Jap. Bot. 28 (1953) 225; ASAHINA, Lich. Japan, Genus Usnea 3 (1956) 113–114, *text fig. 49* and *Plate 24, figs. 1* and *2*.

Usnea sublurida STIRTON, Trans. Proc. New Zealand Inst. 30 (1897–98) 389.

Thallus usually about 150 mm long but attaining 300 mm, pendulous, flexible, smooth, rust red to yellowish laterite or paler or variegated with ashy gray, the short stiff base brown, 1 to 1.5 thick, basally dichotomously branched, the primary branches sympodially branched; secondary branches nearly parallel, terete, gradually attenuate above, often deeply annulate cracked with narrow fissures; thicker branches densely sprinkled with very short slender papillæ, the thinner branches smooth and shiny; all branches deformed by sorediose tubercles. Branchlets many, perpendicular or variously curved, 2 to 10 mm long and often articulate constricted basally, attenuate above, smooth, sprinkled with tubercles, often annulate; tips thin, rather elongate.

Asahina says apothecia are rare, up to 8 mm wide, ciliate, disk ochre yellow, white pruinose. Pale rose to white isidiose soredia on the thinner branches, usually growing singly on tubercles, comparatively large.

Cortex in a New Zealand specimen 180 μ thick. Medulla 200 μ thick, dense, becoming yellow then a beautiful red with K. Axis irregular in outline, 325 μ in diameter, with darker hyphæ interspersed. Others give the cortex from 90 to 150 μ; medulla 120 to 200 μ; axis 300 to 760 μ.

This species is an extreme development of *Usnea rubicunda*, differing in the much larger pendulous thallus and the medullary reaction with K. Their differences are comparable to those between *U. dasypoga* and *U. comosa*.

Known from Japan, Formosa, Australia, and New Zealand, growing on trees. It occurs in the Philippines only in the following form:

USNEA RUBESENS Stirton var. RUBROTINCTA (Stirton) Motyka.

Usnea rubrotincta Stirton, Scott. Natur. 6 (1881) 103.

Usnea rubescens Stirton var. *rubrotincta* (Stirton) Motyka, Usnea Monogr. (1936–38) 348; Asahina, Lich. Japan, Genus Usnea 3 (1956) 114–115, *Plate 24, fig. 3.*

Differs from the typical form in being much smaller, 40 to 60 mm, but rarely more than 60 mm long, erect or prostrate, the main stem dichotomously branched again and again and soon attenuate, not becoming pendulous. Otherwise like the type with which it is often mixed in Japan, but is more widely distributed. Philippine records are as follows: Baguio, Benguet, Mountain Province, Luzon, on pine trees at 5,000 feet; coll. Herre, 1923. Mount Pinatubo, Zambales Mts., Pampanga Province, Luzon, collected by A. D. E. Elmer, May, 1927.

Known elsewhere from Japan, Formosa, Ceylon, Reunion Island, Madagascar, South Africa, St. Helena, the Canary Islands, and the type locality, Madeira.

USNEA ROSEOLA Vainio emend. Asahina.

Usnea roseola Vainio, Bot. Mag. Tol. 35 (1921) 46; A. Zahlbr., Catal. Lich. 6 (1930) 500; Motyka, Usnea Monogr. (1936–38) 363–364; Asahina, Jour. Japan Bot. 25 (1950) 65; Asahina, Lich. Japan, Genus Usnea 3 (1956) 103–106, *text fig. 46* and *Plate 21, fig. 1.*

Thallus up to 130 long, suberect, stiff, in life green, in the herbarium whitish glaucous, opaque, the base about 1 mm thick. Principal stem visibly attenuate above, sympodially branched, the erect branches straight to slightly flexuous, the surface except below verrucose, the warts minute, tuberculate centrally, the globose tubercles white farinose. Branchlets only on the thicker branches. Tips short, blunt.

Apothecia not known. Soredia insidiose, growing on tubercles or warts.

Cortex very irregular, torn within, 50 to 160 μ (Asahina) or 30 to 100 μ Motyka. Medulla dense, 115 to 380 μ thick, the outer part with roseate coloring which disappear with K. Axis 200 to 620 μ thick, irregular in section, solid, occupying 30 to 40 per cent of the diameter of a branch.

A specimen in the Philippine National Herbarium was collected by A. D. E. Elmer on Mount Pinatubo, Zambales Mts., Pampanga Province in May, 1927. Hitherto known only from the islands of Hondo and Kiusiu, Japan.

USNEA FLEXILIS Stirton.

Usnea flexilis STIRTON, Scott. Natur. 6 (1881) 106; A. ZAHLBR., Cat. Lich. 6 (1930) 565; MOTYKA, Usnea Monogr. (1936–38) 126–128; A. ZAHLBR., Cat. Lich. 10 (1940) 584; ASAHINA, Lich. Japan, Genus Usnea 3 (1956) 61–63, *test fig. 34, Plate, 9, fig. 1.*

Usnea furcata Vain. var. *communis* VAINIO, Philip. Jour. Sci. § C 6 (1909) 65. (Not *articulata* as Vainio has it.)

Usnea articulata STEIN, 60 Jahresh. Schles. Gesells. Vaterl. Kultur (1883) 228.

Thallus from about 150 to 250 mm long, soft and often limp, slightly to rather densely dichotomously or subdichotomously branched, never deliquescent, pale straw or pale straw brown color, more or less shiny; base very short, constricted, not blackened, thickened at once, usually to 1.4 mm in diameter. Branches soft, flexuous, smooth, articulate, the segments 5 to 25 mm long, constricted at both ends, the fissures now narrow, now rather wide, the joints sprinkled more or less with minute white rather irregular linear pseudocyphellæ, sometimes slightly farinose between. Branchlets none. Tips elongate, hairlike.

Motyka says apothecia are not rare, but Asahina saw none on Japanese material and I found none on Philippine and New Guinea specimens.

Cortex papery, elastic and almost shiny, 30 to 60 μ thick. Medulla 260 to 385 μ in my sections; 250 μ thick according to Motyka and 450 to 600 μ in Asahina's material. Much depends on whether one selects a moderately or a much inflated segment for sectioning; exceedingly lax, the radiating hyphæ few; yellow with K, finally becoming dark red. Axis rather horny and proportionately very thin, 150 to 180 μ in Philippine specimens;

Asahina gives 130 to 170 μ for Japanese material and Motyka says about 200 μ. Asahina's excellent figure of a section enables one to recognize this strongly marked species with ease.

Specimens have been seen from the following localities: Mt. Data, Lepanto Subprovince, Luzon, at 2,300 meters, collected by E. D. Merrill; Todaye, Mountain Province, Luzon; collected by E. D. Merrill. Beside the trail from Lubuagan and Bañgad, Kalinga Subprovince, Luzon, May 6, 1923, collected by A. W. Herre. Mt. Pulog, Ifugao Subprovince, Luzon; collected by R. C. McGregor, 1909; Summit of Mt. Santo Tomas, Baguio, Benguet, at 7,340 feet, on twigs of *Pinus insularis;* collected by Maj. E. A. Mearns, December 10, 1905. Mt. Pauai, Benguet, Mountain Province, Luzon, at 2,100 meters; collected by R. C. McGregor, 1909; also collected by M. D. Sulit, January 24, 1948. Baguio, Benguet, Mountain Province, Luzon; collected by R. S. Williams, September 24, 1904. Mount Banahao, Quezon Province (Tayabas), Luzon, collected by H. M. Curran, 1904. Mount Apo, Davao Province, Mindanao; collected in 1904 by Maj. E. A. Mearns at 5,700 feet, at the west summit at 9,700 feet, and at the apex at 10,312 feet.

In addition, Motyka had specimens from Mt. Tapulao, Zambales Province, Luzon, collected by Curran and Merritt; and from Canlaon Volcano, Negros, collected by C. S. Banks in 1901. I also examined a specimen collected in New Guinea by L. J. Brass, who obtained it on East Mt., Tafa, Central District.

Since writing the above a specimen was seen from Mt. Katanglad, Central Bukidnon, Mindanao, collected by M. D. Sulit, February, 1949.

This *Usnea* ranges throughout the East Indies through India to East Africa and Madagascar, and from Japan and Formosa to New Zealand. I have a specimen collected by Mrs. Mary Strong Clemens in October, 1949, at Mount Fox, North Queensland, Australia.

USNEA LONGISSIMA Acharius.

> *Usnea longissima* ACHARIUS, Lich. Univers. (1910) 626; Synopsis Meth. Lich. (1814) 307, Nova Acta Reg. Soc. Sci. Upsal. 7 (1815) 194, *Plate 7, fig. 5;* HOWE, Monogr. Usneaceæ U.S. and Canada (1914) 22, *plate 5;* MOTYKA, Usnea Monogr. (1936–38) 423–432; HOWARD, Lichens State of Washington (1950) 160–161, *Plate 11 B;* ASAHINA, Lich. Japan, Genus Usnea 3 (1956) 43–49, *Plate 2.* (For the very extensive synonymy and literature see Motyka.)

Thallus pendulous, elongate, sometimes excessively so, reaching a length of 2 or 3 meters and in the Cascades of Washington state 5 meters or more and 10 meters in the Coast Range of

Oregon. Color varying from ashy to bright or yellowish green or sometimes somewhat silvery, the larger branches becoming nearly white at times. The short base is only 10 to 20 mm long, narrowly dusky, usually lacking in herbarium specimens; thallus base smooth, corticate annulate, 0.5 mm thick or less, dichotomously branched, the secondary branches simple or rarely branching again. Branches very uniform throughout typically 0.5 to 0.8 mm thick, with scarcely attenuate tips, threadlike, usually straight, sort, terete or indistinctly flattened, without cortex, with tartareous or farinose surface which is the medulla. Branchlets numerous, conspicuous, at right angles to the branches and only a little thinner than they are, always smooth and corticate, sometimes branching and sometimes tuberculate basally.

Apothecia very rare, lateral and soon subterminal; excipulum usually convex, smooth, concolorous; marginal fibrils few, rather long; disk flat, pale flesh color, often white pruinose. Soredia none or only abnormal when present.

Cortex present only on branchlets and disappearing on all branches. Medulla thinly scattered along the axis in minute tartareous or farinose clumps, without cortex. Axis occupies almost the whole diameter of the branches, and turns deep blue at once with I.

This beautiful species is easily recognized by its habit, by its numerous branchlets at right angles to the branches, and its reaction with I.

The only Philippine specimen seen was collected by G. A. Lopez near the barrio of Santa Inez, Rizal Province, Luzon. Motyka had specimens from Mt. Data, Lepanto Subprovince and Mt. Pauai, Benguet Subprovince, Luzon, both at 2,100 meters. No doubt it occurs on high mountain all over Luzon.

Care must be taken to separate it from its close relatives, *Usnea hossei, Usnea squarrosa,* and *Usnea squarrosa* var. *misamisensis,* all of which are widely distributed in the Philippines.

Usnea longissima is one of the most widely distributed Usneas, being circumpolar in the northern hemisphere. It occurs from Japan and China across Siberia to the Caucasus, France, and Norway, and from Newfoundland to California and Alaska; it also occurs in the Hawaiian Islands.

USNEA SQUARROSA Vainio.

Usnea squarrosa VAINIO, Philip. Jour. Sci. § C 4 (1909) 654; A. ZAHLBR., Cat. Lich. 6 (1930) 592; MOTYKA, Usnea Monogr. (1936–38) 416–417; ZAHLBR., Cat. Lich. 10 (1940) 605; HERRE, Philip. Jour. Sci. 86 (1957) 35; HERRE, Bryol 63 (1960) 192.

Thallus pendulous, up to 300 mm long, but attaining more than 600 mm in the variety, uniformly pale straw or pale straw green, smooth and shiny up to the branchlets, specimens long in the herbarium darkened with age. Branches opaque, the branchlets smooth and shiny; the base rather stiff; here and there indistinctly annulate, or subannulate. Branches hanging in curves, soon subparallel, uniform, terete, 0.4 to about 1 mm thick, but usually only about 0.7 mm, perceptibly attenuate to the long hairlike tips, continuous but abundantly scurfy or squarrose; that is, frequently but very irregularly broken into areoles, these very blunt, irregularly eroded, flat or rarely elevated with wide shallow fissures filled with paler rough crumbly or tartareous regenerative tissue, the cortex almost vanishing from these; exactly smooth, without papillæ or soredia. Branches abundant but very irregularly arranged, up to 20 mm long, with much longer ones often intermingled but much thinner than branches, variously curved, with attenuate tips, these sometimes rebranched, smooth and shiny, rather freely but indistinctly annulate with very narrow fissures and sparingly sprinkled with corticate warts or tubercles. Tips indistinct.

Apothecia rare, on the tips of branchlets, 3 to 4 mm broad. Disk flat, bluish white pruinose, with very few or almost no marginal fibrils. Excipulum smooth.

Cortex 30 to 40 μ, thick, very soft. Medulla about 70 to 90 μ thick, very dense, white, more or less yellow then deep red with K, afterwards dusky to blackish red. Axis 360 to 380 μ, very hard and solid, blue to deep violet blue with I.

The type was collected by Mrs. Mary Strong Clemens at Camp Keithley, Lanao Province, growing on trees at about 2,200 feet altitude in 1907. The only other Lanao specimen was collected by me at Malabang, growing on trees beside the Constabulary post, altitude about 20 meters, September 24, 1922. Vainio also had a fertile specimen collected by Whitford and Hutchinson at Port Banga, Zamboanga Province. Other Mindanao specimens were collected by Wahrburg at Davao in 1888, and from Mt. Hilong-Hilong, back of Cabadbaran, Agusan Province; the last was collected by Mendoza and Convocar, April 10, 1949, at 833 meters, growing on trees.

Luzon records are as follows: Todaye, Mountain Province, collected by E. D. Merrill, 1911, and distributed in the Kryptog. Exsiv. Mus. Vindob. as No. 1254 B. Vigan, Ilokos Sur Province, collected by Dr.

Schadenberg in 1889. Mt. Arayat, Pampanga Province, alt. about 950 meters; collected by M. Ramos, February, 1905.

Negros records: G. E. Edaño collected it beside Lake Balinsayao, at about 976 meters, where it grew on trees, September, 1948; Negros Oriental Province. Edaño also collected it at Manglangco Sitio, Sibulan Barrio, Negros Oriental Province, at 800 meters, September 23, 1948.

I also examined specimens collected by James Motley in 1852 on Pangangro Volcano, Java, alt. 4,000 to 6,000 feet.

Motyka also had specimens from Lahat, Sumatra, and from above Sambori, Sumbawa, at 4,000 feet, collected by Wahrburg in 1862.

USNEA SQUARROSA var. MISAMISENSIS (Vainio).

Usnea longissima var. *misamisensis* VAINIO, Philip. Jour. Sci. § C 4 (1909) 655.

Usnea misamisensis (Vainio) Motyka, Usnea Mongr. (1936–38) 418–419; (misprinted as *U. misaminensis*); HERRE, Philip. Jour. Sci. 86 (1957) 34; HERRE, Bryol. 63 (1960) 192.

Thallus, 300 to more than 600 mm in length, pendulous, soft, uniformly pale straw, smooth, the base distinct, stiff, frequently branched near the base, rarely so elsewhere. Branches about 0.6 mm thick, basally, regularly attenuate and almost hairlike, little flexuous, terete or very indistinctly deformed, the thicker ones indistinctly annulate and also less frequently broken into areoles, the shallow fissures soon regenerated, the thinner branches continuous. Branchlets abundant, thin, 10 to 30 mm long, erect, attenuate and then almost hairlike, very smooth and nearly shiny. Tips indistinct.

Apothecia rare; there are none on my abundant material; borne on lateral branchlets, small to very small, 0.7 to 5 mm wide, the disk concave to flat, pale flesh color, only slightly pruinose, with very strong fibrils more than 10 mm long.

Cortex 30 to 45 μ thick. Medulla dense, 60 to 90 μ thick, yellow with K. Axis with many dusky hyphæ sprinkled through it, 315 to 560 μ in diameter, blue with I.

When well developed the variety is markedly distinct from the species, but *U. squarrosa* and *U. misamisensis* grade imperceptibly into each other and now and then a specimen occurs which could be placed under either name, so that it becomes impossible to maintain them as distinct species. Motyka says that if it were not for the difference in the axis he would treat *U. misamisensis* as the species and *U. squarrosa* as the subspecies. My reason for taking *U. squarrosa* as the species is that it has page priority.

Vainio had fertile specimens from Mt. Data, Lepanto Subprovince, Luzon, collected by E. D. Merrill at 2,100 meters. The type material was collected by Maj. E. A. Mearns on Mt. Malindang, Misamis Province, Mindanao. Motyka also had it from Mt. Pulog, Benguet, Luzon, collected by Curran, Merritt, and Zschokke in 1909.

In addition to the last two specimens named, I have also examined specimens from the following localities: On the trail between Bangad and Lubuagan, Kalinga Subprovince, Luzon, at about 900 meters altitude; collected by me on May 6, 1923; specimens merging into *U. squarrosa.* Mt. Santo Tomas, near Baguio, Mountain Province, Luzon, growing on pine branches at 2,100 meters altitude; collected by E. D. Merrill. Also specimens collected by Merrill at Todaye, Mountain Province, and on the summit of Mount Mariveles, Bataan Province, Luzon in 1903. The Philippine National Museum has specimens collected by Dr. Eduardo Quisumbing growing on pine trees at 2,100 meters in Mount Santo Tomas, near Baguio, Luzon; also some from near Lake Balinsasayao on the slopes of Los Cuernos de Negros at 976 meters; collected by Edaño in September, 1948. Mount Masapilid, Bontok, Mountain Province, Luzon, collected by Ramos and Edaño. Lamao, Bataan Province, Luzon, collected by H. M. Curran, September, 1907. Mt. Sattelberg in former German New Guinea, at about 900 meters; R. Poch, collector. Dieni, Onange Road, Central District, Papua, New Guinea, common on tree branches at 700 meters, L. J. Brass, collector; he also collected it on East of Mt. Tafa, Central District, Papua, New Guinea, where it was very common in the upper branches of trees at 2,100 to 2,350 feet, May 29, 1933.

Motyka also records it from Tonquin, Assam, Java, Sumatra, Queensland, Australia, and Samoa. This *Usnea* is no doubt occurs in mountain forests everywhere in the Philippines.

USNEA HOSSEI Vainio.

Usnea hossei VAINIO, Annal. Soc. Zool-Bot. Fenn. Van. 1 (1921) 34; MOTYKA, Usnea Monogr. (1936–38) 415–416; ASAHINA, Lich. Japan, Genus Usnea 3 (1956) 52–55, *Plate 5, fig. 1;* HERRE, Philip. Jour. Sci. 86 (1957) 34.

Thallus pendulous, from about 200 to 400 mm or more in length, comparatively stiff, pale straw to ashy green, the rigid dusky base up to 2 mm thick; secondary branches often numerous and much smaller. The main stem about 1 mm thick, smooth, transversely broken with narrow fissures, sparingly dichotomously or subdichotomously branched, or gain abundantly branched. Secondary branches 0.6 to 0.8 mm thick usually but up to 0.9 mm, corticate throughout, the cortex broken into moderate short blunt rings nearly a mm long, the fissures sometimes wide, shallow, pale, farinaceous, the cortex not regenerating. Branchlets erect, abundant, thin, smooth, flexuous, hairlike, rarely more than 10 mm long, stiff, nearly always divergently branched. Tips short, branched almost to their ends, indistinct.

No apothecia or soredia seen. Cortex soft, fragile, only 20 μ thick according to Motyka but Asahina has it 50 to 70 μ; my own sections are 40 to 60 μ. Medulla dense, 75 to 90 μ thick, pale yellow with K; Asahina's measurements are 70 to 150 μ and Motyka merely gives "circa 100 μ," and states yellow to orange yellow with K. The large axis is 485 to 525 μ, speckled with dark hyphæ; blue or violet with I, but sometimes without reaction. Asahina, who had much material, gives the axis as 300 to 600 μ; Motyka merely states 360 μ.

Philippine specimens were examined as follows: On the trail between Bañgad and Lubuagan, Kalinga Subprovince, Luzon, at 2,800 feet, growing on trees; collected May 6, 1923, by A. W. Herre.

On trees at 1,200 meters on the eastern slope of Los Cuernos de Negros, above Dumaguete, Negros Oriental Province; collected by G. E. Edaño, May, 1945. On trees, Mt. Katanglad, Bukidnon Province, Mindanao, April 14, 1949; M. D. Sulit, collector. On trees, Mt. Kampalili, Davao Province, Mindanao; collected by G. E. Edaño, March 23, 1949. Vainio had a specimen collected by H. M. Curran at Lamao, Bataan Province, Luzon.

A typical specimen was collected by Mrs. Mary Strong Clemens in November, 1915, on the Gurulau Spur of Mt. Kinabalu, British North Borneo.

Described from Siam, by Vainio, now Thailand. Through the kindness of Prof. Y. Asahina specimens were examined from Japan, Formosa, and Thailand.

The forma *subtrichodea*, similar to the North American species *U. trichodea*, may well occur on rocks and pine trees on the high mountain of Northern Luzon.

USNEA SCHADENBERGIANA Goeppert and Stein.

Usnea schadenbergiana GOEPPERT and STEIN, 60 Jahresbericht Schles. Gesells. Vaterl. Kultur (1883) 229; MOTYKA, Usnea Monogr. (1936–1938) 414; HERRE, Bryol. 63 (1960) 192.

Thallus pendulous, up to half a meter in length, rather stiff, the color a rather deep straw green. The indistinct base very short, typically dichotomously branched, but densely so only near the base, the secondary branches usually simple. Branches very uniform, about 1.3 mm in diameter, perceptibly attenuate to the tips, terete or very slightly compressed, rather irregularly and clearly freely annulate and broken into areoles, the fissures narrow; without papillæ, smooth, opaque. Branchlets rather abundant, stiff, 20 to 40 mm long, nearly equal in thickness basally, pointed, smooth, shiny, broken into rings except at base.

Apothecia very rare, lateral or subterminal, small, concave; those seen were juvenile; marginal fibrils few, thin, short and long mixed. Disk flesh color suffused with white, becoming almost brown. Excipulum thin. Cortex about 60 μ in thickness, yellowish. Medulla about 100 to 150 μ thick, dense, turning yellow to dark yellow with K. Axis 800 to 1,150 μ in diameter by Motyka's measurements but my sections give 600 to 750 μ and also 925 to 1,050 μ, with a central cavity 225 to 450 μ, or 35 to 40 per cent of the axis, the cavity filled with loose hyphæ, bundles of darkened hyphæ may be present or absent; axis more or less light blue with I.

Only known in the Philippines from the type collection made by Dr. Schadenberg in 1880, at Siriban, on the slopes of Mt. Apo, Davao Province, Mindanao. Collected also by L. J. Brass, May 6, 1933, at Dieni, Onange Road, Central District, Papua, New Guinea, at 700 meters altitude. Specimen seen in the herbarium of the New York Botanical Garden.

Type locality: Siriban, Mindanao, Philippines.

Type in the Botanical Museum, University of Breslau (now Wroclaw, Poland).

USNEA MEARNSI (Vainio) Motyka.

Usnea mearnsi MOTYKA, Usnea Monogr. (1936–38) 391.

Usnea philippina var. *mearnsi* VAINIO, Philip. Jour. Sci. § C 4 (1909) 653.

Thallus about 200 mm long or more, pendulous, pale ashy straw or pale greenish straw color, opaque, the thinner branches paler; base indistinct, thickened, at first simple but soon infrequently dichotomously branched, one branch nearly always better developed, the axils nearly erect and the branches divergent. Primary branches thick above the base, about 0.7 mm in diameter throughout and perceptibly attenuate at the tips which are hairlike, perfectly terete, frequently annulate but also obliquely and irregularly fractured, the breaks at first sharp but soon blunt and regenerating, nearly always very irregular, the fissures narrow at first but soon rather wide; medium branches sharply broken, the thinner ones continuous, perfectly smooth, always opaque, and almost lightly tomentose, without papillæ. Less developed branches generally rare, sometimes nearly erect, very elongate and resembling branchlets. Tips vague, rather freely branched, divergent, hairlike.

Cortex about 100 μ thick. Medulla about 180 μ thick, very dense, red with K. Axis about 250 μ in diameter.

This species is very near *U. diffracta*, a species known from Japan, Korea, and Formosa, and from which it is very narrowly separated. Probably abundant material would show it to be but a variety of *U. diffracta*. As yet only known from the type collection. In general appearance, branching, and annular fractures it is much like *U. trichina*, known from the West Indies, South Africa, and Madagascar.

Type locality: Mount Pauai, Benguet, Mountain Province, Luzon, collected by Maj. E. A. Mearns.

Type in the Botanical Museum, University of Finland, Turku.

USNEA PHILIPPINA Vainio emend. Motyka.

Usnea philippina MOTYKA, Usnea Monogr. (1936–38) 392–393.
Usnea philippina var. *primaria* VAINIO, Philip. Jour. Sci. § C 4 (1909) 653; A. ZAHLBRUCKNER, Cat. Lich. 6 (1930) 589.

Thallus about 300 mm long but certainly attaining a greater length; pendulous, hard, elastic, pale and nearly straw green; inclined to be dusky on the thicker branches, opaque, shiny, smooth; base not seen. At first simple, about 2 mm thick, below and on to the tips rather freely and repeatedly dichotomously and divergently branched. Branches thinner after dividing but rather thick up to tips; these not hairlike, rarely straight but usually flexuous and spirally curved, perfectly terete and only here and there slightly deforned; irregularly annulate throughout besides being longitudinally or irregularly reticulately cracked especially on the thicker branches, the fissures very narrow, sharp, only noticed by the paler longitudinal lines whereby they appear subareolate, smooth, without branchlets. Tips short, indistinct.

Apothecia and soredia unknown.

Cortex about 100 μ thick, elastic, almost glassy. Medulla about 600 μ thick, very dense, white, K-. Axis about 300 μ in diameter whitish flesh color, interspersed with darkened bundles of hyphæ; according to Vainio blue with I.

Only known from the type collection. Near to *U. diffracta,* an *Usnea* of Japan, Korea, and Formosa, and especially close to *U. sublacunosa,* a species known from Oriental Siberia and Sakhalin.

Type locality: Lepanto Subprovince, Mountain Province, Luzon, on Mt. Data at about 7,000 feet altitude, on trees; collected by E. D. Merrill, 1905.

Type in Botanical Museum, University of Finland, Turku.

USNEA MARIVELENSIS (Vainio) Motyka.

Usnea marivelensis MOTYKA, Usnea Monogr. (1936–38) 443; A. ZAHLBRUCKNER, Cat. Lich. **10** (1940) 544; HERRE, Philip. Jour. Sci. **86** (1958) 34.

Usnea furcata var. *marivelensis* VAINIO, Philip. Jour. Sci. § C **4** (1909) 655.

Thallus about 250 mm long, limply pendulous, smooth, soft, beautiful tawny dusky after many years in the herbarium, the thicker branches darker, opaque, the rather indistinct base slightly attenuate; Above the base and throughout its length repeatedly subdichotomously branched. Branches soft, limp, straight, attenuate basally, up to 1.8 mm thick, visibly tapering and nearly hairlike at the tips, plainly articulate, the joints of the thicker branches subinflated, the thinner branches nearly cylindrical, abruptly broken at the margin, which are sometimes slightly limbate, 0.5 to 10 mm long, fissures rather narrow but the medulla visible, all elegantly terete, very glabrous, all without branchlets. Tips very elongate, hairlike, broken into articulations, slightly flexuous, pale straw color.

Apothecia and soredia not seen.

Cortex about 110 μ thick, hard and cartilaginous. Medulla about 300 μ thick, rather dense, white, becoming yellow with K-. Axis about 250 μ thick.

Motyka only saw specimens from the type locality. The U. S. National Herbarium has some of the type collection. The Chicago Museum has specimens from Mt. Masapilid, Bontok Subprovince, Mountain Province, Luzon, collected by Ramos and

Edaño, March, 1920. The Philippine National Museum has specimens from Lake Danao, Sibulan, Negros Oriental Province, collected by G. E. Edaño.

Type locality: Mt. Mariveles, Bataan Province, Luzon. Collected at the summit, growing on trees, by E. D. Merrill, October, 1903.

Type in the Botanical Museum, University of Finland, Turku.

USNEA MONTAGNEI Motyka.

Usnea montagnei MOTYKA, Usnea Monogr. (1936–38) 445; A. ZAHLBRUCKNER, Cat. Lich. 10 (1940) 595.

Thallus elongate, about 550 mm long, pendulous, becoming a beautiful dusky brown in the herbarium, smooth, more or less shiny, the base indistinct, slightly thinner than the thickest branches, soon dichotomously branched throughout the whole length, or more rarely subsympodially branched, the subarcuate branches diverging. Primary branches up to 1 mm thick, regularly attenuate at the tips; the thicker branches subarticulate, the joints 3 to 5 mm long, nearly cylindrical or at least the tips not distinctly tapering, usually irregularly fractured, with margins rather abruptly constricted or at least blunt, not separated, the fissures narrow, irregularly broken; the thinner branches continuous, elegantly terete, smooth, shiny, without pseudocyphellæ; branchlets none; tips elongate, hairlike.

Apothecia not rare, usually on the thinner branches, at first distinctly lateral but later subterminal, 3 to 5 mm wide. Excipulum slightly convex, very smooth, shiny, slightly darker than the branches which are usually rather strong and sometimes again fertile. Marginal fibrils few, unequal, all like the thinner branches. Disk nearly flat, at first slightly concave, the young apothecia densely bluish-white pruinose; adult apothecia often not pruinose or dark flesh color.

Cortex very hard, about 50 μ thick, dusky, medulla about 230 μ thick, rather dense, white, yellow with K, becoming red later. Axis about 400 μ in diameter.

Growing on trees in the East Indies and Philippines. Collected on Mt. Pauai, Benguet, Mountain Province, by Maj. E. A. Mearns in 1907.

Motyka also lists this species from Lamao River, Mt. Mariveles, Bataan Province, Luzon.

Elsewhere it is known from Java, Lombok, and Sumbawa in the East Indies.

The only specimen seen by me was collected at Lake Danao, barrio Sibulan, Oriental Negros Province, by E. B. Edaño.

Type locality: Sambori, Sunbawa; collected by Wahrburg.

Type in the Botanical Museum, Berlin (?), perhaps destroyed during war.

USNEA PYCNOCLADA Vainio.

Usnea pycnoclada VAINIO, Philip. Jour. Sci. § C 6 (1909) 653; A. ZAHLBRUCKNER, Cat. Lich. 6 (1930) 590; MOTYKA, Usnea Monogr. (1936–38) 498–499.

Thallus minute, 18 to 35 mm tall, fruticose, becoming dusky up to the thicker branches in the herbarium, the thinner branches pale straw color, subopaque to shiny, smooth; the base very short, thin, dichotomously branched at once, the secondary branches rather freely divided to the tips. Branches attenuate basally, above soon inflated up to 1 mm thick, plainly attenuate at the tips, terete, the base sometimes articulate, rarely jointed elsewhere, with many short warts and very blunt papillæ over the whole length of the branches, all smooth and all without branchlets. Tips short, thickly clad with short coralloid dichotomous branches.

Apothecia unknown. Soredia rather abundant, growing on the subapical part of branches, rather large, yellowish white, farinose with large granules.

Cortex about 50 μ thick, rather stiff, hard, cartilaginous, dusky. Medulla about 200 μ thick, very lax, to almost none, white, K-. Axis about 130 μ in diameter.

Usnea pycnoclada is close to *U. glabrata,* so near that Motyka is not certain that it is a separate species. It differs from *U. glabrata* in having the thallus distinctly papillate, the tips coralliform and thickly dichotomously branched up to the ends, the branches distinctly paler to their tips and less distinctly articulate, the joints scarcely constricted basally.

Only known from the Philippines and China. The only other record from the Philippines besides the type collection was what I collected above Lake Balinsayao, Negros Oriental Province, where it grew on trees at an altitude of 1,200 meters, March 20, 1922. Motyka had it from Yünnan-fu, China.

Type locality: Mt. Banahao, Quezon Province (Tayabas), Luzon; collected by Curran and Merritt, 1907.

Type in the Botanical Museum, University of Finland, Turku.

USNEA ELMERI Herre, sp. nov.

Thallus parvus, circa 30 to 40 mm longus, basis obscurata. Rami primarii usque 1 mm crassi, obscurati, divergenter sympodialiter ramosis, in herbario ruber ad fuscus. Rami basi articulatum fracti, glaber, soredia isidiosis, rami teniores cum numerosa albida farinosa soralia. Ramuli rari aut nulli, et rami minus evolutis raris simulati.

Cortex 90 to 100 μ, rubricosus ad fulvus, K decoloraris. Medulla laxissima, 345 to 360 μ, K1. Axis 230 to 240 μ in diameter.

Ad arbores, mons Pinatubo, Zambales montes, Prov. Pampanga, Luzon; legit A. D. E. Elmer, May, 1927.

Thallus small, reaching a height of 30 to 40 mm, the principal branches with a diameter of 1 mm, divaricately branched sympodially, the base and primary branches blackened, the general color of specimens after 33 years in the herbarium red to brown. Branches articulate at base, the cortex smooth with numerous rather long white isidiose soredia, the small branches with many white farinose soralia. Branchlets few or none, simulated by poorly developed branches.

Cortex 90 to 100 μ, red to yellow in section, the red disappearing with K. Medulla very lax, 345 to 360 μ, K-. Axis 230 to 240 μ in diamter.

On twigs on Mt. Pinatubo, a peak in the Zambales Mts., Pampanga Province, Luzon. Collected by A. D. E. Elmer, May, 1927. Specimens are in the Philippine National Herbarium.

I take pleasure in naming this *Usnea* after my dear friend and explorer of the Philippine flora, Adoph D. E. Elmer, whose friendship I enjoyed for more than forty years.

USNEA HUMILIS Herre, sp. nov.

Thallus fruticulosus, 40 ad 60 mm altus, 60 ad 80 mm latus, basi brevissima in gomphum dilatata, nigrescente, statim divergenter subsympodialiter ramosa. Rami primarii basi 1 mm et usque 2 mm aut plures crassi. In herbario plus minus rubro-fuscus; rami crassiores rubicundus, rami teniores et ramuli fuscus ad subaquilus, glaber, terete; rami primarii cum papillis cylindricis apice semiglobosus sparsi; papillæ interdum crebre sed sæpe rare. Ramuli crebri, glabri, 1 ad 8 mm longi, erecti aut arcuati ascendentes, ad basin articulati, apices acuminati.

Apothecia parva, usque 4 mm lata; discus planus, pruinosus; excipulum glaber; cilia marginalia mediocra et elongata intermixta, plerumque parva.

Cortex 75 μ crassus. Medulla 385–425 μ crassa, laxissima; K plus, gilva aut rubra. Axis 210 μ in diametro, solidus.

Ad *Pinus insularis,* Baguio, Mountain Province, Luzon, alt, 5,000 pes supra mare; Coll. Adolph D. E. Elmer, March, 1907.

Thallus fruticose, 40 to 60 mm high and 60 to 80 mm wide, erect, the base very short, black, gomphate, at once divergently branching subsympodially. Primary branches from 1 to more than 2 mm in diameter basally. After 53 years in the herbarium specimens are more or less red brown, the larger stems dark red, the smaller branches and branchlets brown to pale brown; smooth, terete, the primary branches sprinkled with cylindrical round-tipped papillæ which are sometimes pointed. Papillæ sometimes dense but more often rather sparse, sometimes continuing almost to the tips of primary branches. Branchlets numerous, almos to the tips of primary branches. Branchlets straight or curved, basally articulate, more rarely jointed elsewhere, mingled with thin and much longer branches which simulate branchlets. The larger branchlets and the branches which simulate them are often torulose.

Apothecia sparingly present, lateral or apparently terminal, up to 4 mm in diameter, the disk flat, probably greenish pruinose in life; excipulum smooth; marginal fibrils small to large, intermingled, usually less than the diameter of the disk.

Cortex 75 μ, yellow to red when seen in section but fading to pale yellow with K. Medulla 325 to 485 μ, very lax, arachnoid, yellow then red with K. Axis 210 μ, solid, without darkened hyphæ; no reaction with K or I.

Growing with *Usnea eumitrioides* on twigs of *Pinus insularis* at Baguio, Mountain Province, Luzon, alt. 5,000 feet. Collected by Adolph D. E. Elmer, March, 1907.

The type is in the National Herbarium, Smithsonian Institution, Washington, D. C.

USNEA RAMOSI Herre, sp. nov.

Thallus cæspitosus, fruticulosus, circa 130 mm longus aut etiam longior et 90 mm latus, basi brevi, nigri; rami primarii plures a basin communi excrescentibus, usque 2 mm incrassati, sat crebre subsympodialiter et subdichotome ramosus; rami plus minus articulatim fracti, ad apices sensim attenuati; terete, glaber, et plus minus nitidi. Papillis brevissi, us concoloribus, rarius sparsi, saepius apice decorticatis et farinosis. Ramulosi pauci ad plures, interdum plurimi, capillacei, acuminati, 1 aut 2 usque 30 mm longi.

Apothecia ignota. Soredia crebra, alba, isidiosa.

In herbario post anni 40 rami primarii sunt rubidus, rami secondarii sunt fuscus, ramuli pallidus.

Cortex flavus aut plus minus ruber, 75–85 μ crassus. Medulla laxissima, alba, circa 450 μ crassa, K-. Axis 255–270 μ in diametro.

Thallus cæspitose, fruticulose, about 130 mm long or more and about 90 mm broad; several primary branches up to 2 mm thick spring from the short black base, freely branching above dichotomously and sympodially; branches jointed and constricted basally and more or less articulate, perceptibly attenuate above, terete, smooth, and more or less shiny. Very low concolorous papillæ thinly distributed, their tips often eroded and white farinose. Branches curved or sinuous, elongate, tapering. Branchlets few to many, sometimes very numerous, usually threadlike, pointed, from 1 or 2 up to 30 mm long, mingled with coarse long fibrils which are poorly developed branches. Tips elongate, threadlike, or often indefinite.

Apothecia unknown. Many white spinelike isidia abundant all over.

A herbarium specimen 40 years old has the primary branches dark red to reddish brown, the secondary branches brown, the branchlets paler to pale tan. The white isidia and farinose soralia contribute to the pale effect.

Cortex in section yellow to more or less red, losing its color with K, 75 to 85 μ thick. Medulla very lax, white; about 450 μ thick, K-. Axis 255 to 270 μ in diameter.

Described from a plant collected by M. Ramos on Mt. Caua, Bontok Subprovince, Mountain Province, Luzon. Similar in some respects to *U. flexilis* but with very numerous isidiose soredia, numerous branchlets, no reaction with K, and with different anatomy.

Called *U. Japonica* by Rasanen but altogether different as shown by material received from Prof. Y. Asahina, as well as by his description in his fine paper on the Usneas of Japan.

The type is in the herbarium of the Chicago Museum of Natural History.

Named for M. Ramos, for many years the modest, quiet, and thoroughly efficient chief plant collector for the Bureau of Science.

USNEA ERECTA (Stein) Motyka.

Usnea erecta MOTYKA, Usnea Monogr. (1936–38) 545–546; A. ZAHLBRUCKNER, Cat. Lich. 10 (1940) 581.

Usnea articulata f. *erecta* STEIN, 60 Jahresber. Schles. Gesells. Vaterl. Kultur (1883) 228; MULL.-ARG., Flora 73 (1890) 336; A. ZAHLBR., Cat. Lich. 6 (1930) 539.

Usnea barbata var. *articulata* f. *erecta* STEIN, 66 Jahresber. Schles. Gesells. Vaterl. Kultur (1888) 133, (proparte).

Thallus about 80 mm long, evidently suberect, strong, in the herbarium yellowish dusky to the thicker branches, the thinner branches and branchlets dusky straw color, shiny or slightly pruinose, especially on the thiner branches. Base indistinct, rather densely branched subdichotomously, the secondary branches almost simple, axils nearly erect. Branches nearly straight, about 1.5 mm thick throughout their length and only attenuate at their tips, terete, continuous or only rarely articulate with widely scattered large subcylindrical papillæ, their tips paler but not farinose, the lower part slightly and unequally wrinkled. Lateral branchlets rather frequent, erect, about 5 mm long, smooth, conical, several times articulate basally, with blunt paler tips. Summits short, thick, ending in apothecia.

Apothecia abundant, terminal, 7 to 10 mm broad, flat or slightly deformed. Excipulum smooth, shiny, dusky. Marginal fibrils many, straight, strong, elongate, resembling branchlets, but stronger, thickly annulate, sometimes recurved, very dusky like the thicker branches. Dish flesh color; in young apotecia densely suffused with bluish green.

Cortex about 100 μ thick, rigid and nearly glasslike, dusky. Medulla about 250 μ thick, the inner part somewhat dense, the outer part lax, yellow with K, then dark red to almost black. Axis about 200 μ in diameter.

First collected by Dr. Schadenberg on the slopes of Mt. Apo, Davao Province, Mindanao in 1882. E. D. Merrill collected it at Benguet, and also at Todaye, Mountain Province, Luzon; some of it was mixed with Kryptog. Exsicc. Vindob., No. 1254. G. E. Edaño secured a specimen at Lake Danao, Sibulan, Negros Oriental Province, but I had no opportunity to make sections. No doubt this species occurs on high mountains throughout the Philippines.

USNEA EUMITRIOIDES Motyka.

Usnea eumitrioides MOTYKA, Usnea Monogr. (1936–38) 322; A. ZAHLBR., Cat. Lich. 10 (1940) 582; on trees and rocks.

Thallus 40 to 60 mm high erect, rather stiff, dark red brown after more than 50 years in the herbarium, branchlets pale brown. Base very short, gomphate, stiff, dusky. Very irregularly and divaricately freely branched; primary branches up to 1.5 mm thick, but rarely over 1 mm, tapering to the tips, terete, often dichotomously branched, continuous or rarely fractured, smooth; minutes papillæ sometimes present on secondary branches. Branchlets abundant, pointed, 0.5 to 5 mm long, mingled with much larger and longer ones which may simulate branches, straight or often irregular.

Apothecia lateral or subterminal, minute and up to 3 or 4 mm in breadth, the disk more or less concave and wrinkled, pale whitish and probably greenish pruinose in life; excipulum smooth, convex; marginal fibrils few, uniform or large and small mingled, pointed, the larger ones longer than the diameter of the disk. Apothecia not reported before.

Cortex 70 to 90 μ. Medulla dense, 160 to 190 μ thick, yellow then red with K. Axis 390 to 405 μ in diameter, with few to darkened hyphæ, usually in bundles but also scattered singly, the darkened hyphæ also yellow, then red with K: I-.

Collected at Baguio, Mountain Province, Luzon, at 5,000 feet altitude, by A. D. E. Elmer, March, 1907; growing on twigs, probably of *Pinus insularis,* mixed with other Usneas. Motyka records it also from Formosa, Anam, and from India.

Type locality: western Province Fukien, near Tingchow, China, on sandstone; altitude about 1,100 meters, 1921.

Type in Mus. Nat. Hist. Nat. Vindob., Austria.

USNEA LÆVATA Motyka.

Usnea lævata MOTYKA, Usnea Monogr. (1936–38) 453–454.

Usnea ciliata VAINIO, Philip. JoJur. Sci. § C. 4 (1909) 654 (not elsewhere and excluding synonymy); A. ZAHLBRUCKNER, Cat. Lich. Univ. 6 (1930) 596 (excluding synonymy).

Thallus of medium size, about 210 mm long (incomplete in the type) thin, pendulous, almost uniformly lurid green, becoming lurid dusky and finally deep red in the herbarium; opaque, subglabrous; base distinct, though not always, thickened, not blackened; secondary bases also forming remote supports; dichotomously branched immediately above the base, or again several times, the branches slightly divergent and variously folded. Branches very uniform throughout their length, and only visibly attenuate at the tips, about 0.7 to 1.0 mm thick, usually serpentine flexuous, perfectly terete, not rarely but very indistinctly annulate from simply fractures, smooth, without papillæ, swellings few, irregular, very indistinct, little elevated and only visible because of their slightly paler color. Branchlets very distinct, 5 to 15 mm long, rarely more, erect but usually serpentine curved or flexuous, thickened basally, and to the attenuate tips, usually about half the diameter of primary branches; summits very indistinct, like short hairs.

Apothecia not known. Soredia not properly observed, growing on tubercles and on branchlets.

Motyka gives the cortex about 35 μ, rather hard. Medulla about 120 μ thick, white, rather lax, deep red at once with K. Axis dusky, about 250 μ in diameter. My sections give the cortex as more or less 50 μ; medulla about 225 μ, at first bright yellow with K but soon red and becoming very dark red next the axis; axis 270 to 280 μ in diameter; no reaction with I.

Only known from the type collection. Some of the type collection was examined at the Farlow Herbarium.

Type locality: Batangas, Luzon; coll. A. M. Curran (not Curzon as Motyka has it) and M. L. Merritt, November 1, 1907.

Type in the Botanical Museum, University of Finland, Turku.

CHEMICAL COMPOSITION OF SOME PHILIPPINE ALGÆ

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INTRODUCTION

The commercial importance of seaweeds in recent years has caused considerable work to be carried out in several countries on their chemical composition and their uses. Seaweeds of different species, some of potential value for food as well as for industrial purposes, abound in Philippine seas. While botanical surveys of some species have been conducted since 1948, principally by Gregorio T. Velasquez, of the Discipline of Botany, University of the Philippines, a study of their chemical composition in connection with their application in the field of nutrition has not been carried out except sporadically.

The need of coordinating chemical investigation with botanical studies by utilizing the materials collected and identified by botanists led to the present work. It is hoped that the study of the chemical composition of the different species of Philippine seaweeds will establish their economic value, and thus, open a field for their greater utilization.

Although seaweeds grow abundantly along the shores of practically all the islands, the lack of knowledge of their chemical composition makes the choice of proper varieties for specific purposes hardly easy. Some species are eaten in certain Philippine localities more for their palatability rather than for their definite food value. In the United States the Pacific kelp industry is centered in the production of agar, algin, and carragenin (an extract from Irish moss) or the "phyco-colloids." In Massachusetts, Maine, and Canada, Irish moss (*Chondrus crispus*) and American dulce (*Rhodomenia palmata*) are industrially processed. In Jamaica, British West Indies, seaweeds are extensively processed with *Torulla* yeast to provide a new source of protein. They promise to stave off protein defficiency in regions where meat supply is a problem.

Current investigations of seaweeds abroad have centered in scientific research and industrial development among the fields of plant growth, hormones, behavior of hydrophyllic colloids, activating effect on agricultural sprays for insecticides, etc. Most of the phyco-colloid production of the United States finds outlets in bakeries and the dairy industries where algin and agar are used as stabilizers. Medical and pharmaceutical preparations make use of alginates as granulating and binding agents.

Because of their transparency, lack of odor, and controlled viscosity, alginates find uses in many varieties of cosmetic preparations. In the paint industry, soluble alginates make possible the preparation of resin emulsions, paints, and varnishes. As fining agent in the clarification of fruit juices and wines, as lubricant in the production of tungsten wires for electric bulbs, as dressing and polishing in the textile industry, alginates are in heavy demand. Recently, alginic fibers have joined the rank of synthetic fibers because they are strong and fire-resistant.

REVIEW OF THE LITERATURE

Work on Philippine seaweeds has often been in connection with their taxonomy or their value as food. On the other hand, investigations in other countries, such as Scotland, Japan, Ireland, India and the United States, center on their identification, relation of chemical composition with season, tide, location, and economic utilization. Among the numerous contributions on chemical composition of seaweeds of different varieties was that of Tomiyasu, et al.(14) who analyzed two varieties of *Sargassum* found in Kyushu, Japan, and reported their moisture (17.25 to 18.04 per cent), ash (80.84 to 21.13 per cent), and alginic acid (21.53 to 29.12 per cent) contents. Isibasi and Shara(8) determined the inorganic elements in the ash of several species by spectroscopic methods; Naransumban and Pal,(11) working on seaweeds gathered along the coastline of Bombay, reported on the cellulose, protein, and iodine contents of *Padina* (18.7 per cent cellulose, 15.2 per cent protein, and 0.0 per cent iodine), *Ulva* (31.0 per cent cellulose, 1.0 per cent protein, and 0.0 per cent iodine), *Enteromorpha* (24.4 per cent cellulose, 2.6 per cent protein, and 0.0 per cent iodine), and red algæ (18.0 per cent cellulose, 7.75 per cent protein, and 4.4 per cent iodine).

Black,(3) of the Scottish Seaweeds Research Association, studied the effect of seasonal variations on the chemical composition of some seaweeds common in Scotland. He studied monthly for two years the percentages of ash, laminarin, crude protein, mannitol and alginic acid in *Ascophylum nedusum, Laminaria cloustini,* and *Laminaria saccharina.* Comparative analyses were made on samples grown in different localities and in different depths—near the shore and in the open sea. Fronds and stipes were analyzed separately. Composition varied widely according to species, depth of immersion, and time-of-year collection.

Shechy, et al.[1] studied the digestibility of *Laminaria* and reported the digestible nutrient of the meal containing 10 per cent moisture to be 50 compared to 20 for potatoes.

Isaac(7) reported the use of South African seaweeds for the production of agar, potash, iodine and alginic acid as well as for human consumption and as fertilizer.

The manufacture of algal chemicals, such as alginates, mannitol, laminarin, and fucoin, has been studied by Barford, et al.(2) and Black, et al.(4) They discussed the experimental methods followed in their work.

In the Philippines, Valenzuela, et al.(15) investigated local seaweeds as sources of agar for pharmaceutical uses. Abelardo(1) determined the nitrogen and iodine contents of samples of *Padina australis, Weeksia* sp., *Gelidium* sp. (red alga) and *Sargassum* sp. and reported the presence of 1.22 to 2.2 per cent nitrogen and 0.03 to 0.55 per cent iodine.

Olea, et al.(12) were the first to determine the moisture, ash, nitrogen, iodine, mannitol and alginic acid contents of Philippine algæ. Samples of *Sargassum* sp., *Padina australis, Ulva fenestrata, Gelidium coulteri,* and *Hydroclathrus cancellatus* were examined.

MATERIALS AND METHODS

The collection made for the identification of the various species found in Philippine waters supplied most of the materials used in the present work. Some of the samples were collected from the U. P. Marine Biological Station at Puerto

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[1] Econ. Proc. Roy. Dubl. Soc. (1942), through C. A. 37 (1943) 694.

Galera; others from Pangasinan, Batangas, and Zamboanga. One sample was furnished by a student of Araneta University, who obtained it from a Manila market.

Owing to the distance from where they were gathered, the seaweeds were received either air-dried or sun-dried. They were washed free of salt and adhering materials, air-dried again, ground in a Wiley mill, sieved in 100-mesh screen, and stored in airtight containers. Figures reported are the average of three or more replications.

Moisture determination.—Moisture was determined by the use of two-gram samples accurately weighed and dried at 105°C for two hours in an electrically heated oven.

Ash determination.—Around two grams of one sample was placed into each of three weighed crucibles, first ignited with the use of open flame at low red heat, then transferred to an electrically heated muffle furnace where they were ashed at 600°C for 2 to 3 hours or until white or grayish-white ash was obtained.

Nitrogen determination.—The Kjeldahl-Gunning method was used for determining nitrogen in the moisture-free samples. Selenium-dioxide pellets or power was used as the catalyst. Distillation was conducted in the manner described by Ynalvez.(16) Factor for convertion to crude protein used as 6.25.

Crude-fat determination.—Weighed moisture-free samples were extracted with c.p. anhydrous ethyl ether and the use of regular Soxhlet extractors.

Crude-fiber determination.—Defatted samples were weighed and placed in beakers containing 200 ml of 0.3 N sulfuric acid and 500 ml of asbestos fiber, then set on a Cenco distillation rack for fiber determination and heated for exactly 30 minutes. The material was next filtered through cheesecloth while hot, then washed with 20 ml boiling water with the use of 200 ml of 0.3 N sodium hydroxide for the transfer. The solution was heated for 30 minutes in the same digestion apparatus, then filtered with the aid of suction through weighed Gooch crucibles provided with asbestos mat. The residue was washed with 20 ml of hot water, then with 20 ml of 95 per cent ethyl alcohol, dried in the oven, cooled and weighed. Crucibles were next ignited in a muffle furnace, cooled, and weighed again. The loss in weight noted was that of the crude fiber in the samples.

Iodine.—Various methods of determining iodine in plants have been reported in the literature. Difficulty in obtaining consistent results was observed. Of the few methods tried, the method of Rasmussen and Bjerreso,(13) which was recommended by E. Booth, of the Institute of Seaweed Research, Midlothian, was adopted. It consisted in mixing the sample placed in a nickel crucible with sodium hydroxide pellets and a "nitrating decomposition mixture" consisting of potassium nitrate, potassium carbonate and anhydrous sodium carbonate. The melt was dissolved in water, treated with concentrated phosphoric acid, then with bromine. The excess bromine was removed by anhydrous formic acid and the iodine liberated was titrated with standard sodium thiosulfate.

Mannitol.—The periodate oxidation method suggested by Malaprade(10) was adopted in preference to the n-butanol extraction method because of the simplicity and accuracy of the former. The method is based on the complete oxidation of one mole of mannitol by five moles of periodic acid. The amount of periodic acid was determined by titration with standard sodium thiosulfate.

Alginic acid.—For the alginic-acid determination, the procedure adopted by Cameron(5) was used. The alginic acid was extracted from the seaweeds with sodium carbonate, and then converted to calcium alginate admixed with some calcium carbonate. On acidification, the free acid is estimated as acetic acid liberated from the calcium-acetate solution.

RESULTS AND DISCUSSION

Algæ geenrally undergo, variations in composition in view of such factors as species, location, depth of growth and time of-year collection. Most of the samples studied were of the genus *Sargassum.* This genus thrives best in tropical waters and can give variations that make it difficult for botanists to properly classify them. Plants exposed to open seas have been found to have different compositions from those collected along protected shores. Table 1 shows the sources of the different species of seaweeds analyzed. Table 2 summarizes the results obtained with the methods of analysis used for the determination of moisture, ash, crude fat, nitrogen, crude fiber, alginic acid, etc., from the samples, the figures representing the averages of at least three or more replications.

TABLE 1.—*Sources of seaweeds analyzed.*

Specimens	Date of collection	Place of collection	Nature of drying
Sargassum siliquosum (C. Ag.) (4476)*	October 31, 1959	Hundred Is., Pangasinan	Sun
Sargassum granuliferum (C. Ag.) (4477)	do	do	do
Sargassum granuliferum f (?) (4478)	do	do	do
Sargassum granuliferum (C. Ag.) (4478a)	do	do	do
Sargassum Binderi Sonder (4479)	do	do	do
Sargassum Binderi Sonder (4481)	November 1, 1959	Anda, Pangasinan	do
Sargassum Binderi Sonder (4482)	do	do	do
Sargassum Binderi Sonder (4482a)	do	do	do
Sargassum Binderi Sonder (4484)	November 2, 1959	Bolinao, Pangasinan	do
Eucheuma muricatum (Gmelin) Weber van Bosse (4484a)	do	do	do
Halymenia sp. (4484b)	do	do	do
Sargassum ilicifolium (C. Ag.) (4485)	do	do	do
Largassum ilicifolium (C. Ag.) (4486)	do	do	do
Sargassum ilicifolium (C. Ag.) (4487)	do	do	do
Sargassum sp. (4488)	December 27, 1959	Burgos, Ilocos Norte	Ventilated room
Sargassum sp. (4489)	do	do	do
Sargassum sp. (4489a)	do	do	do
Sargassum ilicifolium (C. Ag.) (4491)	December 28, 1959	do	do
Sargassum ilicifolium (C. Ag.) (4492)	December 29, 1959	do	do
Sargassum ilicifolium (C. Ag.) (4493)	do	do	do
Sargassum ilicifolium (C. Ag.) (4494)	do	do	do
Codium (sp.) (4561)	May, 1961	Puerto Galera	do
Halymenia durvillaei Bory (4562) (red)	do	do	do
Halymenia durvillaei Bory (4563) (bleached)	do	do	do
Sargassum sp. III	March, 1960	Hundred Is., Pangasinan	Air dried
Sargassum sp. IV	September, 1960	do	do
Sargassum sp. V	do	do	do
Sargassum sp. VI	do	do	do
Sargassum sp. VII	do	do	do
Red Alga			do
Glacilaria salicornia		Dagat-dagatan, Malabon, Rizal	do
Hydroclathrus cancellatus		Diniguian Island	do
Hypnea musciformis		Dagat-dagatan, Malabon, Rizal.	do
Tuninaria trialata		Zamboanga City	do

TABLE 2.—*Chemical composition of seaweeds.*

Specimen	Moisture	Ash	Crude fat	Crude fiber	Crude protein
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Sargassum siliquosum (C. Ag.) (4476)	15.20	15.72	0.96	10.62	8.75
Sargassum granuliferum (C. Ag.) (4477)	14.40	17.37	0.98	10.34	9.87
Sargassum granuliferum f(?) (4478)	16.19	16.65	0.77	10.71	9.93
Sargassum granuliferum (C. Ag.) (4478a)	16.23	17.71	0.88	10.92	8.87
Sargassum Binderi Sonder (4479)	16.18	16.53	1.07	10.93	8.06
Sargassum granuliferum (C. Ag.) (4481)	15.56	19.27	0.87	9.34	8.12
Sargassum Binderi Sonder (4482)	18.69	18.90	0.94	9.07	9.18
Sargassum Binderi Sonder (4482a)	12.74	18.7	0.55	11.12	5.20
Sargassum Binderi Sonder (4484)	13.20	13.87	0.75	11.39	6.75
Eucheuma muricatum (Gmelin) Weber van Bosse (4484a)	20.35	15.02	0.68	5.03	5.04
Halpmenia sp. (4484b)	17.69	30.22	0.95	2.04	11.75
Sargassum ilicifolium (C. Ag.) (4485)	11.23	14.7	2.15	4.15	14.83
Sargassum ilicifolium (C. Ag.) (4486)	15.21	18.58	1.44	5.45	7.01

* Herbarium numbers are enclosed in parenthesis.

TABLE 2.—*Chemical composition of seaweeds*—Continued.

Specimen	Nitrogen	N.F.E.	Crude fat	Mannitol	Iodine
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Sargassum siliquosum (C. Ag.) (4476)	1.40	48.75	20.40	37.55	5.02
Sargassum granuliferum (C. Ag.) (4477)	1.58	47.04	26.46	29.20	6.72
Sargassum granuliferum f(?) (4478)	1.59	45.75	32.17	29.19	3.97
Sargassum granuliferum (C. Ag.) (4478a)	1.42	45.39	20.96	35.51	4.72
Sargassum Binderi Souder (4479)	1.29	47.23	19.13	41.71	4.82
Sargassum granuliferum (C. Ag.) (4481)	1.30	46.84	29.46	27.58	3.76
Sargassum Binderi Sonder (4482)	1.31	44.22	35.07	44.53	0.87
Sargassum Binderi Sonder (4482a)	0.83	51.69	15.29	29.36	1.57
Sargassum Binderi Sonder (4484)	1.08	54.31	2.22	36.65	1.53
Eucheuma muricatum (Gmelin) Weber van Bosse (4484a)	0.81	53.88	1.59	25.41	2.82
Halymenia sp. (4484b)	1.88	37.35	1.7	31.77	0.30
Sargassum ilicifolium (C. Ag.) (4485)	2.38	53.00	30.97	8.33	2.85
Sargassum ilicifolium (C. Ag.) (4486)	1.09	52.31	11.45	16.78	2.47

TABLE 2.—*Chemical composition of seaweeds*—Continued.

Specimen	Moisture	Ash	Crude fat	Crude fiber	Crude protein
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Sargassum ilicifolium (C. Ag.) (4487)	17.68	13.89	0.47	12.86	7.06
Sargassum sp. (4488)	11.12	14.33	1.061	11.84	6.68
Sargassum sp. (4489)	16.10	26.97	0.849	9.52	8.25
Sargassum sp. (4489a)	17.26	13.51	1.26	7.81	7.84
Sargassum ilicifolium (C. Ag.) (4491)	11.25	17.11	1.60	8.89	6.74
Sargassum ilicifolium (C. Ag.) (4492)	16.76	14.10	1.38	13.55	7.87
Sargassum ilicifolium (C. Ag.) (4493)	10.75	14.14	2.16	2.32	19.85
Sargassum ilicifolium (C. Ag.) (4494)	14.35	12.12	2.09	5.75	6.74
Codium sp. (4561)	8.10	57.74	1.21	4.85	4.97
Halymenia durvillaei Bory (red) (4562)	14.04	31.52	0.66	2.36	12.75
Halymenia durvillaei Bory (Bleached) (4563)	18.40	31.34	0.53	2.82	11.87
Sargassum sp. III	7.45	12.88	1.42	8.98	6.51
Sargassum sp. IV	19.78	19.67	1.30	9.50	9.32
Sargassum sp. V	15.42	27.41	1.51	10.15	7.77
Sargassum sp. VI	18.93	21.51	0.51	7.54	10.56
Sargassum sp. VII	17.78	22.69	0.60	10.34	8.18
Red alga	3.83	30.53	0.43	3.09	16.93
Gracilaria salicornia	9.01	12.26	0.78	3.55	10.62
Hydraclathrus cancellatus	12.6	15.4	1.02	1.62	8.96
Hypnea musciformis	8.64	12.10	0.75	1.20	10.34
Tuninaria trialata	13.35	14.48	1.63	9.02	7.17

The moisture content of the different samples varied considerably, ranging from 8.10 (No. 4561) to 20.35 per cent (No. 4484a); but, in general, the average was about 15 per cent moisture. Since the samples were previously dried, it was not possible to compare the moisture content of fresh samples with that reported in other countries, which varied from 67 to 90 per cent. The values reported here can only serve as an indication of the water-retentive capacity of the different varieties.

TABLE 2.—*Chemical composition of seaweeds*—Continued.

Specimen	Nitrogen	N.F.E.	Alginic acid	Mannitol	Iodine
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Sargassum ilicifolium (C. Ag.) (4487)	1.13	48.04	26.77	36.51	3.49
Sargassum sp. (4488)	1.07	54.969	8.92	33.80	3.089
Sargassum sp. (4489)	1.32	38.311	4.46	24.62	1.306
Sargassum sp. (4489a)	1.25	52.32	41.44	37.75	8.05
Sargassum ilicifolium (C. Ag.) (4491)	1.07	54.41	5.10	33.56	1.44
Sargassum ilicifolium (C. Ag.) (4492)	1.26	46.34	27.41	23.07	0.894
Sargassum ilicifolium (C. Ag.) (4493)	3.17	50.78	29.65	4.34	1.84
Sargassum ilicifolium (C. Ag.) (4494)	1.07	58.95	39.53	7.91	3.01
Codium sp. (4561)	0.796	23.13	1.77	40.59	1.94
Halymenia durvillaei Bory (red) (4562)	2.04	38.67	2.04	35.47	6.21
Halymenia durvillaei Bory (Bleached) (4563)	1.90	35.04	1.91	29.55	5.39
Sargassum sp. III	1.04	62.76	21.67	10.57	1.71
Sargassum sp. IV	1.48	40.43	28.66	36.63	5.74
Sargassum sp. V	1.23	37.74	26.14	24.96	3.02
Sargassum sp. VI	1.67	40.95	25.17	31.22	2.49
Sargassum sp. VII	1.31	40.41	36.32	33.32	4.10
Red alga	3.18	45.19	3.82	33.06	2.12
Gracilaria salicornia	1.70	63.78	0.95	7.03	1.90
Hydraclathrus cancellatus	1.32	60.37	4.46	21.11	2.09
Hypnea musciformis	1.65	66.97	1.91	14.07	2.49
Tuninaria trialata	1.14	64.35	17.20	8.39	no more sample

TABLE 3.—*Chemical composition of seaweeds as analyzed by Olea, et al.*

Specimens	Moisture	Ash	N_2	I_2	Mannitol	Alginic acid
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Corallopsis	24.40	15.36	0.92	2.28	6.52	4.83
Gelidium coulteri Harvey	15.85	15.71	2.02	9.23	10.10	17.24
Hydroclanthrus cancellatus	10.85	38.01	0.91	1.35	17.26	7.25
Sargassum sp. (fruiting)	16.57	15.83	1.42	26.3	10.07	10.70
Sargassum sp.	18.85	15.16	0.82	4.56	14.02	30.40
Sargassum sp. dried (Boaya Point)	11.36	24.68	1.02	8.7	8.03	7.30
Sargassum sp. (young)	20.11	17.03	1.95	4.30	13.71	39.18
Sargassum sp. (old)	17.41	24.65	1.17	4.05	10.22	29.48
Padina australis	18.22	20.20	1.98	2.23	6.50	28.69
Padina australis	16.15	45.47	0.95	2.14	5.69	22.30
Ulva fenestrata	22.86	22.98	0.58	3.36	8.03	1.83

The ash content, which serves as an index of the quantity of inorganic constituents of the plants, averaged around 16 per cent. Higher values were found in some species such as *Codium* (No. 4561), with 57.74 per cent ash; *Halymenia* (No. 4484b), 30.22 per cent; *Sargassum* (No. 4489), 26.97 per cent; and a red alga from a local market, 30.53 per cent. Variation in the ash content of Canadian seaweeds from 12.3 to 45 per cent was also observed by Macpherson and Young.(9) The ash used to be a source of alkali for the soap industry in Britain prior to the adoption of the Le Blanc process.

There was small variation in the nitrogen content in the different species. The lowest value, 0.796 per cent, was obtained from *Codium* sp. (No. 4561); the highest, 3.18 per cent was from red alga. The values reported for crude protein were obtained by multiplying the nitrogen values by 6.25 for comparison with seaweeds reported from other countries. *Sargassum hornie* and *S. microcanthum* as reported by Tomiyasu et al,(14) contained 14.32 and 12.51 per cent, respectively. Nothing has been reported on the nutritive value of the seaweeds as source of protein; but Fisher and Burlew investigated the calorific value of the dry plants and report that *Laminaria digitata,* possible source of food, contained 280.2 calories.

Seaweeds seem to be poor sources of fat. Of the samples analyzed, only two species of *Sargassum* (Nos. 4493 and 4494) gave an average of over 2 per cent of crude fat, the rest varied from 0.43 to 1.63 per cent.

Crude fiber is important in the evaluation of animal feed since animal nutrition studies in the United States have shown that allowable limits of crude fiber should be between 7 and 9 per cent. Mortality in chickens increases as the crude-fiber increases. In addition, it is reported that the growth of chicks decreases as crude fiber in the feed increases. Only a few of the samples analyzed were found in the range recommended; and it appeared that in the *Sargassum* species, the values were rather high, the highest being 13.35 per cent. Could this be the result of the method of collection employed? Since an investigation of the whole plant is of interest in studies of its chemical composition, would it be advisable to obtain the fronds far from the holdfast?

The values obtained for alginic acid in *Sargassum* ranged from 1.27 per cent to 39.53 per cent, with an average of 21.52 per cent. Lunde and his coworkers, according to Chapman,(6) reported the alginic-acid content of various species as ranging from 15 to 40 per cent. The acid is believed to occur in the form of metal salts. A private enterprise[2] is undertaking the collection of seaweed samples from different part of the islands, and is sending them abroad for analysis. It is interested in the commercial exploitation of alginates.

The mannitol content of the samples varied from 4.34 (No. 4493) to 40.49 (No. 4561) per cent. Except for three species of *Sargassum,* the percentage of mannitol averaged over 30 per cent. In some species, both the alginic acid and mannitol were high; in others, mannitol values were consistently higher than those of alginic acid.

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[2] The Compañia General de Tabacos de Filipinas.

The iodine content of the species studied showed wide variation, i.e. from 0.87 (No. 4482) to 6.21 (No. 4562) per cent. These values compare favorably with those reported from India by Naransumban and Pal.(11)

It is planned to identify and determine the amount of such inorganic constituents as calcium, phosphorus, iron, potash and bromine, in addition to the iodine content investigated in this work. Presently, interest is centered in the value of seaweeds as a source of inorganic salts in animal feed, and in the use of seaweed manure as a source of trace elements for growing plants.

Likewise, the mineral composition of the ash is expected to be studied in the future. The importance of calcium and phosphorus in animal feed is well known. As the role of mineral constituents in fertilizers has already been established, algæ may prove of value as fillers in fertilizers formulations.

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STUDIES ON THE BIOLOGY OF PHILIPPINE MOSQUITOES

II. OBSERVATIONS ON THE LIFE AND BEHAVIOR OF AEDES ALBOPICTUS (SKUSE) IN THE LABORATORY

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In the first part of this series, some bionomic features of *Aëdes ægypti* were discussed. The present paper deals with laboratory observations on the life and habits of *Aëdes albopictus,* another member of subgenus *Stegomyia,* which is of considerable interest in this country and elsewhere, because of its role as a vector of dengue fever [Simmons, et al.,(8) Mertems,(6) and Snijders(9)]. It has also been found to transmit yellow fever in the laboratory [Dinger, et al.(3)] and there is no reason why it could not do the same in nature. If ever yellow fever makes its appearance in this country, the presence of *Aëdes albopictus,* in addition to *Aëdes ægypti,* the classical vector, could pose a problem.

Aëdes albopictus is very common and widespread in the Philippines, especially in and around urban centers, like Manila. The adults and larvæ are often found in association with *Aëdes ægypti. Aëdes albopictus* is a persistent biter on humans, mostly during the day. It bites in the open as well as indoors. It breeds usually in various artificial containers in and around houses.

To date, however, there has been no serious work on *Aëdes albopictus* in this country. The little information we have about *Aëdes albopictus* is merely incidental to mosquito surveys in connection with our malaria and filaria-control activities. It seems worthwhile, therefore, to present the results of our laboratory observations on various aspects of its biology to supplement our knowledge of its habits. The information may be of some use in future control programs.

A colony was started from larvæ and pupæ collected from water stored in barrels around houses in the vicinity of the Institute of Malariology at Tala, Caloocan, Rizal. The techniques employed were essentially the same as those used in raising and keeping *Aëdes aegypti,* as described in the first paper of this series. At this writing, the colony of *Aëdes albopictus* is in the twenty-second generation. The stock on hand provided a continuous supply of relatively uniform materials for various observations.

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* With the assistance of Messrs. Ananias Diaz and Rodolfo Cajara.

All experiments were carried out in an insectary in which the average monthly temperature varied from 24° to 29″C and the mean relative humidity from 80 to 93 per cent.

EXPERIMENT 1. EGG-LAYING PREFERENCES

The object of this experiment was to determine what extrinsic factors influence oviposition by the gravid female. One of the colony cages was used for this observation. Four tests were performed as follows:

Test 1.—Two halves of Petri dishes provided with water-soaked pads of cotton and covered with fitting circles of white filter paper, and another two with unprotected plain water, were placed inside the cage. Thus, for egg-laying, the females had the choice between damp filter paper and open water. Counts for six days are shown in Table 1*a*. In all cases, open water was preferred for oviposition.

Test 2.—The oviposition dishes with unprotected plain water in Test 1 was then replaced with dishes containing water-soaked layers of cotton and covered with fitting circles of black filter paper (painted with India ink). Their places were also interchanged. Thus, for egg-laying, they had the choice between white and black filter paper as substrates. The results of six replicates are shown in Table 1*b*. In all cases, significantly more eggs were laid on black filter paper.

Test 3.—The oviposition dishes with black filter paper was next replaced with dishes provided with smooth substrates (onion-skin paper). Their places in the cage were also altered. Thus, for egg-laying, they now had the choice between rough (filter paper) and smooth (onion-skin paper) surface. The results of six replicates are shown in Table 1*c*. In four out of six trials, rough substrate was selected for oviposition.

Test 4.—In another cage, the eggs laid between 6:00 a.m. and 6:00 p.m. were counted separately from eggs laid between 6:00 p.m. and 6:00 a.m. of the following morning.

During the day, both natural and artificial lights were used in the insectary where this observation was performed. Natural light entered through four windows (3′ × 1′). Artifi-

TABLE 1.—*Oviposition preferences of Aëdes albopictus in the laboratory.*
a. Damp filter paper vs. open water.

Replicate number	Number of eggs laid	
	Damp filter paper	Open water
I	337	1,402
II	448	840
III	149	759
IV	112	765
V	185	891
VI	70	252
Total	1,301	4,909

b. White filter paper vs. black filter paper.

Replicate number	Number of eggs laid	
	White, damp, filter paper	Black, damp, filter paper
I	75	752
II	305	622
III	140	530
IV	98	543
V	88	301
VI	58	520
Total	764	3,268

c. Rough vs. smooth substance.

Replicate number	Number of eggs laid	
	Rough	smooth
I	684	98
II	464	273
III	730	819
IV	350	91
V	304	444
VI	592	475
Total	3,124	2,200

cial light was provided by three 40-watt fluorescent ceiling bulbs. Inside the cage the light intensity was only about five-foot candles, as measured by a Weston foot-candle meter. At night, the artificial lights were shut off, so that there was almost total darkness.

The results of the counts for fourteen days are shown in Table 2. The results showed significantly that more eggs were laid during daylight hours, when the light intensity inside the cage was not more than five-foot candles. Obviously, the females prefer to lay eggs under low illumination rather than under complete darkness.

TABLE 2.—*Influence of light on the ovipositing female Aëdes albopictus in the laboratory.*

Replicate number	Number of eggs laid: 6:00 a.m. to 6:00 p.m. (Light intensity) (5-foot candles)	Number of eggs laid: 6:00 p.m. to 6:00 a.m. (Total darkness)
I	1,083	517
II	486	330
III	856	231
IV	1,427	1,203
V	835	905
VI	934	613
VII	1,326	565
VIII	1,279	322
IX	3,249	2,648
X	1,754	775
XI	579	95
XII	1,604	878
XIII	763	258
XIV	2,031	362
Total	18,206	9,702

EXPERIMENT 2. VIABILITY OF EGGS

The object of this experiment was to determine the effect of maturation, desiccation, and low temperature on the viability of the eggs. By maturation is meant allowing the embryos to attain full development. This was accomplished by storing the eggs shortly after deposition, together with the damp filter paper on which they were laid, in tightly stoppered bottles for three or four days. For hatching, the mature eggs were placed directly in water.

To determine the value of maturation, three tests were made as follows:

Test 1.—Mature versus immature eggs: Six halves of damp filter paper containing a total of 1,300 eggs, not more than 16 hours old, were matured for three days, after which they were immersed in water for hatching. The other six halves were immersed directly in water shortly after deposition. The number that hatched within a week after immersion in each group was then noted down.

The results, as shown in Table 3, indicate no significant difference in viability between the two groups.

Test 2. Viability after desiccation for 2, 4, 8, and 12 weeks.—Filter papers with 200 eggs each (not more than 16 hours old) from the same batch were dried at room temperature for 2, 4, 8, and 12 weeks. After the indicated periods of desiccation,

TABLE 3.—*Viability of matured and nonmatured eggs of Aëdes albopictus.*

Trial number	No maturation			With maturation		
	Number of eggs	Number hatched	Per cent viable	Number of eggs	Number hatched	Per cent viable
I	250	185	74.00	250	157	62.80
II	200	156	78.00	200	165	82.50
III	200	171	85.50	200	164	82.00
IV	200	167	83.50	200	160	80.00
V	300	190	63.33	300	192	64.00
VI	150	97	64.66	150	80	53.33
Total	1,300	966	74.31	1,300	918	70.62

they were immersed in water and the rate of viability within a week after immersion was noted.

The results of two replicates are shown in Table 4. The table shows that eggs could withstand drying at room temperatures for as long as three months and still be viable. For laboratory purposes, however, desiccated eggs should be used within one month to insure good results.

TABLE 4.—*Resistance of nonmatured eggs to desiccation.*

Weeks dried	Number of eggs	Number hatched	Per cent viable
2	400	241	60.00
4	400	173	43.00
8	400	124	31.00
12	400	37	9.00

Test 3. Effect of low temperature on viability.—Damp filter papers containing 1,000 eggs (not more than 16 hours old) were placed in a Petri dish and stored in a refrigerator for one month (temperature control was set at medium range). After that period, they were removed and placed in water to hatch. Only 5 per cent hatched. However, when an equal number of eggs was first matured for three days prior to storage under the same conditions, 37 per cent was viable, apparently indicating that maturation increases resistance to low temperature.

EXPERIMENT 3. TIME OF FIRST BLOOD MEAL AFTER EMERGENCE

The object of this observation was to determine the time of first feeding after emergence. For this purpose, 200 females which had emerged the previous twenty-four hours were isolated in a 1-foot-cube cage. They were then offered human blood for 30 minutes in the morning and those which refused to feed the first day were again given the chance to feed the next day, and so on, until all had fed. Feeding was done by inserting the writer's or the assistant's arm inside the cage for at least 30 minutes.

The results given below show that Philippine *albopictus* mostly takes first blood meal two days after emergence:

Number of mosquitoes used	200	
Number fed on 1st day after emergence	33	(16.5 per cent)
Number fed on 2nd day after emergence	126	(63.0 per cent)
Number fed on 3rd day after emergence	38	(19.0 per cent)
Number fed on 4th day after emergence	3	(1.5 per cent)

EXPERIMENT 4. EGG TO ADULT LIFE SPAN

In more than one thousand eggs (1,300 eggs) immersed directly in water not long after deposition, and observed for one week, hatching took place from the second day but mostly on the fourth and fifth days, as shown below:

Number of eggs tested	1,300	
Number hatched on 1st day	0	
Number hatched on 2nd day	9	(less than 1 per cent)
Number hatched on 3rd day	71	(7.35 per cent)
Number hatched on 4th day	283	(29.19 per cent)
Number hatched on 5th day	411	(42.55 per cent)
Number hatched on 6th day	132	(13.66 per cent)
Number hatched on 7th day	61	(6.31 per cent)

In more than 200 isolations, the length of development from hatching to pupation varied from 5 to 9½ days, and from pupation to emergence from 1¼ to 3½ days. The larvæ were reared in white enamelled pans containing 1-inch of tap water, with chicken mash as feed. Approximately 300 larvæ were reared in one pan to avoid overcrowding.

To summarize, the egg-adult life span varies as follows:

Oviposition to hatching	2–7 days, ave. 5 days
Larval stage	5–9½ days, ave. 7 days
Pupal stage	1¼–3½ days, ave. 2½ days
Egg to adult	8¼–20 days, ave. 14¼ days

During the period of observation, the average monthly temperature was 25.5°C and a mean relative humidity of 87 per cent.

EXPERIMENT 5. LONGEVITY OF ADULT MALES AND FEMALES

Two observations were undertaken to determine the longevity in the laboratory of the adult males and females.

Test 1.—Two hundred males and females which had emerged the previous 24 hours were placed in a 1-foot-cube cage. Sugar solution (5 per cent) was accessible at all times. After two days and daily thereafter blood meal was offered for at least 30 minutes, by inserting a human arm into the cage. The sugar solution was intended primarily for the males, but it also served as supplementary feed for the females. To provide high humidity, wet rags were placed over the sides and top of the cage. Oviposition dishes were also provided for the females. The number of deaths were recorded daily. Mean temperature: 25°C; RH, 84 per cent.

The results are shown in Table 5. The maximum survival for the females was 87 days: for the males, 65 days.

TABLE 5.—*Longevity of Aëdes albopictus males and females which had fed on blood and sugar.*

Longevity	Males		Females	
Days	*Number*	*Per cent*	*Number*	*Per cent*
1-12	28	14.0	15	7.5
13-20	41	20.5	17	8.5
21-30	68	34.0	55	27.5
31-40	20	10.0	45	22.5
41-50	37	18.5	30	15.0
51-60	5	2.5	14	7.0
61-70	1	0.5	9	4.5
71-80	0	0.0	12	6.0
81-90	0	0.0	3	1.5
Total	200	100.0	200	100.0

Test 2.—Two cages were used, each containing 200 females. They were maintained under the same temperature and humidity conditions (mean temperature: 26°C; RH, 85 per cent). For feed, blood meal was provided in Cage 1; 5 per cent sugar solution in Cage 2. The number of deaths in each group was recorded daily. The results are shown in Table 6. The

TABLE 6.—*Comparative longevity of two groups of Aëdes albopictus, one which had fed on blood only, and the other on sugar solution.*

Longevity	Fed on sugar only		Fed on blood only	
Days	*Number*	*Per cent*	*Number*	*Per cent*
1-12	15	7.5	66	33.0
13-20	21	10.5	37	18.5
21-30	15	7.5	36	18.0
31-40	25	12.5	19	9.5
41-50	45	22.5	22	11.0
51-60	28	14.0	17	8.5
61-70	31	15.5	3	1.5
71-80	17	8.5	0	0.0
81-90	3	1.5	0	0.0
Total	200	100.0	200	100.0

maximum survival, when fed with human blood meal only, was 61 days, as against 82 days in the group fed with sugar solution only.

EXPERIMENT 6. DURATION OF GONOTROPHIC CYCLE AND THE NUMBER OF EGGS PER BLOOD MEAL/FEMALE

Gonotrophic cycle as used here denotes the time interval between feeding and laying of eggs.

An undetermined number of pupæ from the colony was allowed to emerge in a 1-foot-cube cage. After 2 days, the adults were offered human-blood meal. A large number of males also emerged in the cage, so that presumably the females were fertilized. This was confirmed by the presence of spermatozoa in the spermatheca of a few females dissected. After feeding, each engorged female was isolated in a small lamp chimney, about 3 inches high, 1 inch diameter at the top, and 1½ inches diameter at the bottom. The top was covered with fine bobbinet while the bottom was set over a circle of white filter paper, which in turn was placed over a pan, the bottom of which was provided with a layer of water-saturated fine sand covered with a double layer of filter paper. A wad of wet cotton was also placed over the top end of each lamp chimney. The wetting of the bottom of the pan as well as the wad of cotton over each isolation was renewed from time to time.

Examination for eggs was done daily in the morning. After eggs had been laid, the mosquitoes were re-fed and records of the succeeding gonotrophic cycles noted down. The following data were obtained.

First gonotrophic cycle (200 cycles)

Duration in days	Number	Per cent	Remarks
1 to 2	5	2.5	Mean temperature 26°C
3 to 4	123	61.5	Mean RH 81 per cent
5 to 6	51	25.5	
Above 6	21	10.5	

Later gonotrophic cycles (142 cycles)

Duration in days	Number	Per cent
1 to 2	10	7.0
3 to 4	107	76.0
5 to 6	22	15.0
Above 6	3	2.0

The foregoing data show that in the majority of instances the duration of the gonotrophic cycle was from 3 to 4 days. It can be seen also that, whereas in the first gonotrophic cycle 61.5 per cent laid eggs from 3 to 4 days after feeding, in the later cycles 76 per cent laid eggs in the same period. This is to be expected, owing to the fact that after oviposition the ovaries are already in Stage II and not in Stage I, as is the case in newly emerged females.

In 342 ovipositions, a total of 15,588 eggs were laid or an average of 46 per laying. The maximum number laid was 124, the minimum 6.

Out of 342 egg-layings, 284 or 83 per cent were laid after single blood meals, while 58, or 17 per cent after multiple feedings. The number of eggs laid after single blood meals averaged 46, as compared with 41 for those which laid after multiple blood meals. Apparently, there was no significant difference in the number of eggs laid by the two groups.

Out of 200 females, 112, or 56 per cent, laid eggs once only; 59 or 29.5 per cent, twice; 16, or 8 per cent three times; 7, or 3.5 per cent, four times; 4, or 2 per cent, five times; and 1 each laid seven and nine times.

The number of eggs laid per blood meal and per female are given in Table 7.

TABLE 7.—*Number of eggs laid per blood meal and per female of Aëdes albopictus in the laboratory.*

Number of eggs/blood meal		Number of eggs/female	
Number of females	Number of eggs	Number of females	Number of eggs
17	15–19	86	Less than 50
34	20–29	73	50–100
41	30–39	20	101–150
43	40–49	8	151–200
34	50–59	6	201–250
10	60–69	1	251–300
10	70–79	2	301–350
9	80–89	1	351–400
0	90–99	2	401–450
1	100–109	0	451–500
0	110–119	0	501–550
1	120–129	1	551–600
Total— 200		200	

EXPERIMENT 7. CYCLE OF DIURNAL ACTIVITY

A total of 400, 48-hour-old females, in groups of 100, were released in a screened room, approximately 24′ × 10′ × 10′, at about 5:00 a.m. Natural light entered the room through four windows (3′ × 1′). In addition, artificial illumination was provided by three 40-watt fluorescent ceiling lights. The temperature of the room during the period of observation was 26°C; relative humidity, 89 per cent.

From 6:00 a.m. to 6:00 p.m., two persons stayed in the room and the mosquitoes which bit them were caught and recorded by the hour. The results of the catches are shown in Table 8.

The data show that *Aëdes albopictus* is most active during the the early hours of the morning. Thus, out of 323 caught biting, 200, or 62 per cent fed from 6 to 8 a.m.

TABLE 8.—*Diurnal activity of Aëdes albopictus in the laboratory.*

Time to catch	Number caught biting	Per cent	Remarks
6– 7 a.m.	159	49.23	A total of 400 females was released in the room. Mean temperature, 26°C Mean relative humidity, 89 per cent
7– 8 a.m.	41	12.69	
8– 9 a.m.	21	6.50	
9–10 a.m.	23	7.12	
10–11 a.m.	16	4.95	
11–12 p.m.	13	4.02	
12– 1 p.m.	10	3.10	
1– 2 p.m.	18	5.57	
2– 3 p.m.	4	1.24	
3– 4 p.m.	8	2.48	
4– 5 p.m.	5	1.55	
5– 6 p.m.	5	1.55	
Total	323	100.00	

EXPERIMENT 8. COMPARATIVE MAN OR ANIMAL FEEDING PREFERENCE OF AEDES ALBOPICTUS.

Three tests were performed to compare the feeding preference of females used in our laboratory.

(1) *Man versus chicken.*—Seventy-two-hour-old females in groups of 20 were released in 10″ × 12″ × 16″ cages. Then they were allowed to feed for 15 minutes, with a chicken and a human arm as sources of blood meal. Careful observation was made and the number which fed on either host were caught and recorded accordingly. The results of ten replicates showed that 84 per cent gorged on human, as against 16 per cent on chicken.

(2) *Man versus mice.*—The figures obtained showed that 88 per cent fed on human, as against 12 per cent on mice.

(3) *Man versus rabbit.*—In a third observation, 81 per cent fed on man, as against 19 per cent on rabbit.

Thus, in all three instances, man was definitely the preferred host.

EXPERIMENT 9. RESISTANCE OF LARVÆ AND PUPÆ TO DRYING AND THEIR SUBSEQUENT VIABILITY

These tests were performed in Petri dishes using 50 larvæ or pupæ in each test. Halves of Petri dishes were covered with discs of filter paper cut to fit the bottom and sides. The larvæ or pupæ, as the case may be, was then pipetted on to the paper, care being taken to avoid flooding them with too much water. The dishes were then placed uncovered in a suitable place in the insectary and allowed to dry at room temperature. They were examined after 24 and 48 hours. After the inspection and the number of survivors counted, they were restored to normal conditions, and observed for pupation and emergence. During the period of observation, the mean temperature was 26°C and the relative humidity 87 per cent.

The results are summarized in Table 9. The figures obtained showed that first-, and second-instar larvæ were all killed by one day of drying. However, the third-, and fourth-instar larvæ were able to withstand the same period of exposure. In the latter case, mortality was 40 per cent, pupation 45 per cent, while only 39 per cent developed to adults. But third-, and fourth-instar larvæ were all killed after drying for two days. In the case of the pupæ, mortality was 45 per cent after one day of desiccation, but only 7 per cent emerged into adults. Two days of desiccation likewise killed all pupæ.

TABLE 9.—*Resistance of larvæ and pupæ of Aëdes albopictus to drying and their viability after such exposure.*

Larval instars	Days dried	Larvæ or pupæ	Mortality	Pupation	Emergence
		Number	*Per cent*	*Per cent*	*Per cent*
I-II	0	50	10	78	60
I-II	1	100	100	0	0
I-II	2	100	100	0	0
III-IV	0	50	0	100	96
III-IV	1	100	40	45	39
III-IV	2	100	100	0	0
Pupæ	0	50	4	-----------	96
Do	1	100	55	-----------	7
Do	2	100	100	-----------	0

In the first part of this series dealing with *Aëdes ægypti*, the same tests were also made but the experimental dishes were kept covered, so that a more favorable condition occurred. It was possible that the same results would have been obtained had these tests been made identical conditions.

EXPERIMENT 10. RESISTANCE OF LARVÆ AND PUPÆ TO LOW TEMPERATURE

Fourth-instar larvæ and pupæ in groups of 100 contained in Petri dishes 3½″ dm and ¾″ deep, were placed in a refrigerator (temperature control set at medium range) for 1, 3, 5, and 7 days. Another set of larvæ and pupæ were observed as control. After the indicated periods of exposure to low temperature, they were removed and placed inside the insectary where the mean temperature was 26°C and relative humidity 86.5 per cent. The mortality in each case was recorded. The survivors were then observed for pupation and emergence. The results are shown in Table 10.

TABLE 10.—*Resistance of larvæ and pupæ to low temperatures and their viability after such exposure.*

Number of days placed in the refrigerator	Larvæ or pupæ	Mortality	Pupation	Emergence	Remarks
	Number	*Per cent*	*Per cent*	*Per cent*	
0	50	8.0	92.0	84.0	Temperature control set at medium range.
1	200	1.5	57.5	52.5	
3	200	52.0	27.5	25.0	
5	200	79.0	10.0	8.0	
7	200	94.0	1.0	1.0	
0	50	0.0	----------	100.0	
1	200	6.5	----------	85.5	
3	200	27.5	----------	20.0	
5	200	57.0	----------	4.0	
7	200	34.0	----------	0.0	

As shown in the table, 48 per cent of the larvæ survived three days, 21 per cent, five days, and 6 per cent, seven days. But beyond three days' exposure, viability was almost nil. Likewise, the pupæ survived the same period of exposure, but after five days, only 4 per cent developed to normal adults, while after seven days, not even one emerged.

DISCUSSION

In the laboratory, *Aëdes albopictus*, like *Aëdes ægypti*, readily lays eggs on damp filter paper, open water, cotton pads wet with sugar solution, or any damp or moist surface inside cages. It was further noted that there was a predilection for laying eggs in creases and fissures of damp filter paper substrates. Between rough and smooth surfaces, the former was much more highly preferred for oviposition. With *albopictus*, in contrast with *ægypti*, open water was preferred for egg-laying. In open water, the eggs of *albopictus*, like those of *ægypti* are concentrated on the sides of the oviposition pan, just above the water level, although there are numerous eggs strewn over the water surface.

Various investigators [Jobling,(4) Bates,(1) Lund,(5) de Zulueta,(2)] have reported female mosquitoes being attracted to water with a dark background color. In the laboratory, *Aëdes albopictus* exhibited a decided preference for laying eggs on dark filter paper substrates.

A mosquito species adapted to breed in temporary artificial containers may be faced with the problem of survival during the dry season, especially during prolonged dryness. It is not surprising, therefore, that the eggs of *Aëdes albopictus* are very highly resistant to drying. The eggs can withstand drying at room temperature for as long as three months, and still be viable, but, of course, at a much reduced rate. The larvæ and pupæ, on the other hand, can withstand drying for short periods only, although under conditions of incomplete desiccation, it is possible that they can survive up to four days and still produced normal adults.

Shannon and Putnam(7) working with the eggs of *Aëdes ægypti* stressed the importance of the "conditioning" of eggs as a preliminary to hatching. They found that it requires 2 to 3 days at 25°C for the embryo to develop and reach a stage that would permit immediate hatching. The eggs of *albopictus* conditioned or matured in this manner prior to immersion in water for hatching, are not superior in hatching to eggs immersed directly in water shortly after oviposition. It seems that maturation, however, increases resistance to desiccation and exposure to very low temperatures.

Under normal conditions at temperatures between 24° to 29°C, the egg to adult life span of *Aëdes albopictus* takes two weeks, more or less. The first blood meal is usually taken two days after emergence. Oviposition follows in 3 to 4 days. The average number of eggs laid per blood meal (human) was 46 and a female can lay as many as nine batches of eggs during her life in the laboratory. However, 85 per cent of the experimental adults laid eggs once or twice only. After single blood meals, 83 per cent laid eggs, while 17 per cent did so after two or more feedings.

In the laboratory, the females fed upon chicken, rabbit, or mice but man is the preferred host. Of the experimental females 62 per cent fed voluntarily during the early morning hours when released in a spacious room. However, they would feed at any time of the day or night inside the cage when offered a human-blood meal. In another observation, two groups of 48-hour-old females (100 in each group) were offered human-blood meal—one group from 3 to 4 p.m., while the other group from 8 to 9 p.m. (under complete darkness). The results of two replicates showed that 66.5 per cent fed during daylight hours; 52.5 per cent during the night—obviously indicating slightly higher preference for daytime feeding. The females are tenacious biters and once the proboscis is inserted, they are hard to dislodge. A host (man) may walk a distance without driving the biting females. They will fly away only when fully blooded. The bite of *albopictus* seems relatively less itchy than that of *ægypti.*

Like *Aëdes ægypti, albopictus* males and females mated readily in the cage during daylight hours when the light intensity inside the cage was not more than 5-foot candles. Any disturbance inside the cage causing them to fly seemed to incite copulation.

Adult females when fed with human blood and sugar solution lived up to 87 days; males 65 days. Females when fed with blood meal (human) only survived up to 61 days, as compared to 82 days when fed with sugar solution only. The females, therefore, are fully capable of living long enough to transmit Wuchererian infections or viral diseases, of which this species is a potential or actual vector.

SUMMARY AND CONCLUSIONS

1. The life span of *Aëdes albopictus* from egg to adult at temperatures ranging from 24° to 29°C, is two weeks, more or less.
2. The first blood meal is taken usually 2 days after emergence.
3. The gonotrophic cycle lasts from 3 to 4 days.
4. *Aëdes albopictus* prefers to lay eggs on open water rather than on damp filter paper. In the choice of substrate, dark was preferred to white, and rough to smooth surfaces.
5. *Aëdes albopictus* seems to have a little more propensity to lay eggs under low light intensity than in complete darkness.
6. The eggs can survive maturation or "conditioning" but it is not necessary to insure high viability.
7. The eggs are very resistant to desiccation and can withstand drying at room temperatures up to three months and still remain viable.
8. Maturation increases resistance of eggs to desiccation and very low temperatures.

9. Resistance of larvæ and pupæ to drying is of short duration, but it is probable that under conditions of incomplete desiccation, they could survive up to four days and still produce normal adults.

10. The larvæ and pupæ can survive five days' exposure to very low temperatures and produce normal adults.

11. Adult females can live up to three months; the males up to two months under laboratory conditions.

12. Adult females are most active in the early morning hours, but they feed at other times of the day and even at night.

13. Man is the preferred host, but *albopictus* feeds also on animals if given no other choice.

14. *Aëdes albopictus* is predominantly a day biter. As such, it is very likely that it may often be interrupted in its feeding by abrupt movements of the host while working, and thus be made more dangerous as a vector of disease, since it viciously bites again and again and may attack different persons until it is fully gorged.

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PRELIMINARY REPORT OF THE JOINT PHILIPPINE-AMERICAN ECLIPSE EXPEDITION TO CANTON ISLAND, SOUTH PACIFIC *

By F. N. Glover, S.J.

The Manila Observatory, Ateneo de Manila University, was recently invited by the U. S. National Bureau of Standards to participate jointly in an eclipse expedition to Canton Island, in the South Pacific. The object of the expedition was to make measurements of the ionization in the earth's upper atmosphere during the period of the eclipse, February 5, 1962, to be used in studying the processes of ion production and recombination in the ionosphere. The National Bureau of Standards offered to supply all the necessary equipment but requested the assistance of the Manila Observatory in making the observations. Fr. Francis Glover, S. J. of the Manila Observatory and Mr. G. H. Stonehocker of the Bureau of Standards jointly made the necessary observations.

Canton Island in the South Pacific was selected as the site for observations. Canton Island (Latitude 2° 46′ South, Longitude 171° 43′ West) lay almost in the path of totality, and the eclipse occurred there shortly after noon. Air transportation between Honolulu and Canton Island was furnished by the Federal Aviation Agency. All equipment was functioning properly on the day of the eclipse, and the observational data obtained appear to be valid.

In this article the nature of the research problem and the type of observations made on Canton Island will be presented. Since the data obtained have still to be processed abroad by a high speed electronic computer, the final results of the trip are still forthcoming.

The sun's radiation causes the gases of the earth's upper atmosphere to become ionized, that is, the incoming solar photons are able to detach one or more electrons from an atom or gas molecule in the upper atmosphere. The rate of ionization depends upon the number of incident photons, the number of target

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atoms or molecules, and the relative size, or "cross section" of the incident and target particles.

Although the "cross section" for a given gas with respect to photons of a given energy is constant, the number of gas particles decreases exponentially with height above sea level, while the number of incident unabsorbed photons increases exponentially with height, attaining a maximum value at the top side of the earth's atmosphere. Thus the rate of photoionization, q, of a given gas, i.e., the number of ions produced per cubic centimeter per second, is a function of the height above sea level, h. Symbolically, the rate of photoionization is q(h).

Since a state of ionization is electrically unstable, the positive and negative particles tend to recombine, even while other neutral atoms are being ionized. Usually a steady state is reached, with the rate of photoionization balanced off by the rate of recombination of the ions. There are, however, several different processes of recombination.[1] The simplest process is that of radiative recombination, which is just the reverse of photoionization, i.e., the positive ion captures a free electron and becomes as neutral atom, and the excess energy of the free electron is given off as radiation. Symbolically, this may be expressed as

$$0^+ + e^- \rightarrow 0 + h\nu. \qquad (1)$$

Theoretical considerations can predict the average time for a group of such ions to recombine by this process. The time is however much in excess of observed recombination rates.

A more promising recombination scheme is a two-stage process. The first stage is termed atom-ion exchange, in which the positive ion steals an electron from a neutral molecule, such as oxygen or nitrogen. Thus

$$0^+ + 0_2 \rightarrow 0 + 0_2^+ \quad 0^+ + N_2 \rightarrow 0 + N_2^+ \qquad (2)$$

Such a reaction is possible since the ionization potential of O_2 is less than that of 0 , and the system naturally seeks the condition of minimum energy.

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[1] Bates, D. R. Recombination in the Ionosphere. Solar Eclipses and the Ioniosphere. Pergamon Press, London (1956) 191–197.

The second stage of the two stage recombination process is that of disassociative recombination, namely, the ionized molecule, O_2^+ for instance, captures a free electron, and disassociates into two atoms of neutral oxygen:

$$O_2^+ + e^- \rightarrow O + O, \qquad (3)$$

Note that after the first stage, (2), there is no net decrease in the number of ionized particles. If the two stages do not take place with equal rapidity, it is clear that the slower stage will be the "bottle neck." The rate of the ionization will be approximately equal to the rate of the slower of the two stages.

Let n be the number of free electrons per unit volume in the upper atmosphere. This number, n, will vary with the height above sea level, h, and also with time, t. Mathematically this is equivalent to the statement, $n = n(h, t)$.

Likewise let N(h) be the number of neutral molecules, O_2 or N_2, per unit volume, available for atom-ion exchange. N(h) is a function of height alone. Actually we do not know beforehand the numerical value of N(h), nor of q(h), the rate of photoionization, nor even which of the two stages of recombination, (2) or (3), will have the slower rate. However the free electron density as a function of height and time, n(h, t), can be measured.

The rate of atom-ion exchange, (2), will be proportional to the number of ions, n(h, t) and to the number of neutral molecules, N(h), available. Since the exact proportionality constant is unknown, as is also N(h), these two may be lumped together into a single height dependent parameter, $\beta(h)$, to yield the atom-ion exchange rate.

$$\beta(h)\, n(h,t). \qquad (4)$$

The rate of disassociative recombination, (3), will be proportional to the number of free electrons, n (h, t), and to the number of molecular ions (O_2^+, for instance) which is also equal to n(h, t). Thus the disassociative recombination rate is

$$\alpha\, n(h,t)^2, \qquad (5)$$

where α is a constant independent of both height and time.

During the course of the day, the number of free electrons, n(h, t), will vary, not only due to the changing amount of incident solar radiation, but also due to vertical drift motions in the ionosphere. However during the short period of a solar eclipse the incident solar radiation will be changing at a known rate, but rapidly enough to permit us to neglect the effect of vertical drifts of ionization. During such a period, the rate of photoionization will be

$$E(h,\ t)\ q(h)\ \ \text{electrons/second/cubic centimeter.} \qquad (6)$$

where E(h. t) expresses the fraction of the sun's disc covered by the moon as viewed from a given altitude, h, and at a given time, t. Since we have excluded appreciable vertical drift motion during the period of the eclipse, the following relation is valid:

$$\begin{bmatrix}\text{Rate of change of}\\ \text{free electrons}\end{bmatrix} = \begin{bmatrix}\text{Rate of}\\ \text{Photoionization}\end{bmatrix} - \begin{bmatrix}\text{Rate of}\\ \text{Recombination}\end{bmatrix} \qquad (7)$$

Depending on which of the two rates, (4), or (5), is the slower, and therefore the governing rate for the recombination process, we have one or the other of the following equations:

$$\frac{\Delta n(h,t)}{\Delta t} = E(h,t)\,q(h) - \begin{cases} \beta(h)\, n(h,t) \\ \text{or} \\ \alpha\, n(h,t)^2 \end{cases} \qquad (8)$$

These may be rearranged as follows:

$$\left[\frac{\Delta n(h,t)}{\Delta t} \cdot \frac{1}{n(h,t)}\right] = q(h)\left[\frac{E(h,t)}{n(h,t)}\right] - \beta(h), \qquad (9)$$

or

$$\left[\frac{\Delta n(h,t)}{\Delta t} \cdot \frac{1}{n(h,t)^2}\right] = q(h)\left[\frac{E(h,t)}{n(h,t)^2}\right] - \alpha \qquad (10)$$

For the period of the eclipse it is possible to observe n(h, t) and to compute E(h, t). For any given height, q(h) and β(h) will be constant, while the quantities in the brackets are known or easily computed. If (9) is the correct relation, then for a fixed height, h_o, a graph of

$$\left[\frac{\Delta n}{\Delta t} \cdot \frac{1}{n}\right] \quad \text{versus} \quad \left[\frac{E}{n}\right]$$

will give a straight line with a slope of $q(h_o)$ and an intercept $\beta(h_0)$. Similar graphs for other heights will yield approximate value of β and q at these heights.

If however (10) is the proper relationship, a set of plots of

$$\left[\frac{\Delta n}{\Delta t} \cdot \frac{1}{n^2}\right] \quad \text{versus} \quad \left[\frac{E}{n^2}\right]$$

will result in a set of straight lines, all with the same intercept, α, and with slopes varying with the changing value of h.

This method of analysis, then, will give the photoionization rate, q(h) and also the effective recombination rate, α or $\beta(h)$, depending on which is the controlling factor. Measurements made of the ionization during the solar eclipse of October 12, 1958 at Danger Island, in the South Pacific, were subject to a similar analysis. The results indicated that (9) is the relationship to be employed. However the values for q(h) and $\beta(h)$ thus obtained were several times in excess of previous observations by other methods.[2] For this reason it was felt desirable to make observations during the 1962 solar eclipse to verify the previous work.

The quantity of ionization in the upper atmosphere at a given time may be measured by transmitting vertically upwards pulses of radio frequency energy of a known frequency, and measuring the intensity and the delay time of any returned echoes. The free electrons in the upper atmosphere are forced to oscillate in the electric field of the oncoming wave, and if the number of electrons is great enough, the incident wave will be totally reflected. In a region of the ionosphere of electron density n, all incident waves of frequency greater than some critical frequency, f_c, will be totally reflected, while higher frequency waves can pass right through this region. The relation between the electron density, n, and the critical frequency, f_c, is

$$n = \frac{f_c^2 \; m}{e^2} \; k \; .$$

where e and m are the charge and mass of the electron, respectively, and k is a constant dependent on the system of units employed. For the observations at Canton Island, a special electronic instrument, called an ionosonde, was used. This instrument is essentially a low frequency radar transmitter and receiver which automatically transmits on various frequencies and plots on 35 mm film the returned echoes as a function of frequency and delay time.

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[2] Van Zandt, T. E., R. B. Norton, and G. H. Stonehocker. Photochemical rates in the equatorial F2 region from the 1958 eclipse. Journ. Geophy. Res. 65 (1960) 2003.

The activity on Canton Island consisted in setting up and operating such an ionosonde during the eclipse of February 5, 1962, and for several days before and afterwards. More than five hundred individual records were produced, and these film records have been forwarded to the U. S. Central Radio Propagation Laboratory to be processed on their high speed electronic computer, to yield a table of values of the electron density, $n(h, t)$ for the time of the eclipse. These values can then be used to evaluate the expressions $q(h)$ and $\beta(h)$ of equation (9). This analysis will take several months to complete and evaluate.

THE NUCLEAR PREDICATION IN SANGIR

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The Sangir dialect is spoken in the Sangir Islands, an archipelago of Indonesia lying directly south of the Sarangani Peninsula, Philippines. During the past 40 years groups of Sangir have immigrated to the Philippines, settling on the islands of Balut and Sarangani, as well as the southern coastline of Cotabato and Davao. The estimated number now in the Philippines is 6,000 to 8,000. The present study of the Sangir dialect was made over a period of one year, while living in the sitio of Maluko, Sarangani I., under the auspices of the Summer Institute of Linguistics.

Sangir is a member of the Malayo-Polynesian language family, as are the dialects of the Philippines. Similarities have therefore been found between it and the various Philippine dialects, especially in the grammar. One difference is the occurrence of only two sets of pronouns. An acquaintance with these pronouns is essential to the proper understanding of the Sangir nuclear predication. A discussion of the pronouns is therefore introduced at this point.

IDENTIFICATION OF PRONOUNS

The two pronoun sets in Sangir are the *ia'* and the *-ku,* of which the singular forms are:

ia' Set		*-ku* Set	
ia'[1]	first person singular	*-ku; taku'*	first person singular
ikau	second person singular	*-u, -nu*	second person singular
isie	third person singular	*-e, -ne*	third person singular

Identical forms occur in the plural for both sets:

ikadua	first person dual inclusive
ikite'	first person plural inclusive
ikaduaini	first person dual exclusive

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[1] The symbols used to indicate Sangir phonemes follow in general the traditional Malayo–Polynesian phonemic notation. Exceptions to this rule are as follows: *e* is the high close central unrounded vocoid, *w* is the voiced bilabial fricative, *gh* is the voiced velar fricative, *ng* is the voiced velar nasal, *rl* is the voiced retroflexed flapped lateral, and ' is glottal stop.

ikami	first person plural exclusive
irua	second person dual
ikamene	second person plural
irĕdua	third person dual
sisire	third person plural

All forms listed as occurring with the initial *i-* (for example, *ikau, isie*) have been found to occur also without the *i-*. The first person singular form *ia'* is the only exception to this.

When the directional *su* is used in combination with the *ia'* set, it is prefixed to the pronoun, the *u* being lost in the process:

sia'	first person singular
sikau	second person singular
sisie	third person singular
sikadua	first person dual inclusive
sikite'	first person plural inclusive
sikaduaini	first person dual exclusive
sikami	first person plural exclusive
sirua	second person dual
sikamene	second person plural
sirĕdua	third person dual
sisire	third person plural

Members of the *ia'* set occur as independent forms, while the singular forms of the *-ku* set are suffixes: *ia' makoa' sarang Gaĕng.* I (*ma*) make towards Glan. I'm going to Glan. *ene bĕliĕngku.* that buy (*ĕng*)-I. That's what I'll buy.

The *ia'* set may function as either the actor or the goal of the action, while the *-ku* set has only an attributive function: *ia' mĕngunsa' pakeang.* I (actor) (*mĕng*) wash-clothes. I'll wash clothes. *ia' niwanting konsul.* I (goal) (*ni*) punish Consul. I am punished by the Consul. The *-ku* set may be attributive to both nouns and verbs. When attributive to the former it indicates possession; and when attributive to the latter it indicates the non-topic actor, which we shall call "agent." *asuku mapaelĕ'.* dog-my beautiful. My dog is beautiful. *laku' ene bĕliĕngku.* dress that buy (*ĕng*)-I (agent). I'll buy that dress (or, That dress is my buying).

The first person singular of the *-ku* set occurs in two forms—the suffixed *-ku* form, and the full *taku'* form. The *taku'* form stands in construction with only verbs and thus functions as agent in constructions in which a non-actor is topic. It occurs preceding the verb: *laku' ene taku' bĕliĕng.* dress (goal) that I (agent) buy (*ĕng*). That is the dress I'll buy (or, That dress is my buying).

The morphemes *-u, -nu* you, and *-e, -ne* he, use *-u* and *-e* after consonants and *-nu* and *-ne* after vowels: *laku'u* your dress, *asunu* your dog, *laku'e* his dress, *asune* his dog.

NUCLEAR PREDICATIONS

In a Sangir verb, affixation may simultaneously signal relationships on the clause level and also on the word level. Since the minimum obligatory unit of the Sangir action sentence is the predication plus topic construction, and since this construction is the core from which the rest of the sentence expands, it has been termed the nuclear predication. The structure of this clause-level unit is in part determined by the affixation of the verb. The same affixes when broken down into their component parts reveal lexical features on a word-level. Both levels of analysis will be described in this paper.

Nuclear predications are composed of the topic and the verb complex. The verb-complex consists of the agent and the verb, including the affixation. The nuclear predication may form a complete minimal sentence[2]: *ia' maiang.* I (topic-actor) (*ma*) sit. I'll sit. The actor here is *ia'*, and it is also the topic. *laku' taku' bĕliĕng.* dress (topic-goal) I (agent) buy (*ĕng*). I'll buy the dress. The verb-complex here is *taku' bĕliĕng* I buy (or, my buying); the topic is the goal, or object *laku'* dress.

The minimal sentence may be expanded as follows: *pia' laku' mapaelĕ' taku' bĕliĕng su toko.* have dress (topic-goal) beautiful I (agent) buy (*ĕng*) at store. There is a beautiful dress at the store I'm going to buy. The nuclear predication is the same in both cases.

The topic of this nuclear predication is that high-lighted element, closely related to the action, which, together with the action, controls the remainder of the sentence.[3]

The agent in a nuclear predication may occur as a substantive, as a pronoun, or it may be unexpressed: *laku' bĕliĕng bawine.* dress (topic-goal) buy (*ĕng*) woman (agent). The woman will buy the dress (or, The dress is the womon's buying). *laku'*

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[2] Richard S. Pittman defines a complete minimal sentence as a construction of not less than one verb and one substantive, which may constitute an entire monologue with no dependence on preceding or following linguistic or gesture context other than that of a pronoun referent.

[3] This particular syntactic relationship between topic and action has been termed "voice" in other publications by members of the Summer Institute of Linguistics. *See* The Inflection and syntax of Maranao Verbs, Howard McKaughan, Manila, 1958.

bĕliĕnge. dress (topic-goal) buy (*ĕng*)-she (agent). She will buy the dress (or, The dress is her buying). *laku' bĕliĕng.* dress (topic-goal) buy (*ĕng*) (woman, unexpressed). The woman (unexpressed) will buy the dress (or, The dress is the woman (unexpressed)'s buying).

Nuclear predications in Sangir have been identified on the grounds of (*1*) their component parts (topic plus agent plus verb, with affixation), (*2*) syntactic relationship of the verb-complex to the topic, and (*3*) the position in the sentence of the item to which the verb-complex is primarily related (the topic).

The affixation of nuclear predications is charted in the following manner:

Nuclear Predications:

Phase	Genius	Time		
Resultant	State	Incomplete	ma–	mi . . . Ø
		Complete	na–	ni . . . Ø
	Process	Incomplete	mang–	Ø . . . ang
		Complete	nang–	ni . . . ang
Purposive	State	Incomplete	mĕ'–	i . . . Ø
		Complete	nĕ'–	ni . . .
	Process	Incomplete	mĕng–	Ø . . . ĕng
		Complete	nĕng–	ni . . . ĕng

On the syntactic or clause level two major divisions have been observed in Sangir nuclear predications: (*1*) Subjective, and (*2*) Objective. In the Subjective nuclear predications the topic is the actor, and in the Objective nuclear predication the topic is the goal of the action: *ia' mĕmĕli laku,.* I (topic-actor) (*mĕng*) buy[4] dress. I'll buy the dress. *laku' taku' bĕliĕng.* dress (topic-goal) I (agent) buy (*ĕng*). I'll buy the dress (or, The dress is my buying).

On the lexical or word level nuclear predications reveal three divisions: (*1*) Phase, (*2*) Genius, and (*3*) Time. There are two phases.[5] As it relates to Sangir constructions, Phase is that property of an action that indicates whether the results of that action are within or without the action-word.

One phase, in which the results are within the verb, indicates the existence or the production of a state or condition. This particular phase has been termed Resultant. The main thrust of the action is the describing of a quality or the effecting of a state. The action may be thought of as having an inner terminal.

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[4] The nasal in this and other prefixes is assimilated to the point of articulation of the initial consonant of the base; the consonant of the base is then lost.

[5] Phase is a state between changes in appearance, structure, character, as defined in Webster's Collegiate Dictionary.

Examples of the Resultant Phase: *isie masongo kodang.* he (topic-actor) (*ma*) arrive yet. Has he arrived yet? *ma'eng seng sělihě' dumarleng maira' sasi' raki'u maněbu.* if already current (-*um*-) walks (*ma*) forceful sea (topic-actor) result (*mang*) foam. If the current is strong the sea will be foaming.

The other phase, in which the results are outside the verb, indicates an action performed by, on, or for a person or thing. This phase has been designated Purposive. The main thrust here is the performance of the action itself for a purpose that is not inherent in the action. In a Purposive Phase the action has an external target, or terminal.

Examples of Purposive Phase: *ia' tamai mě'dea' kalu.* I (topic-actor) proceed (*me'*) look-for wood. I'm going to look for wood. *ikami su januari měngatu' barle.* we (topic-actor) in January (*měng*) roof house. In January we will roof the house.

In addition to the Phase there is a further division in the verb of a nuclear predication. This has been called Genius, for it describes the distinctive nature of the action. Genius has two categories: (*1*) State, and (*2*) Process.

In the State Genius the action is described with respect to its state or quality of subsistence. The action is positive, direct, and restricted as to time, place, and contributing factors. Examples: *isire maotong su Marore.* They (topic-actor) (*ma* Resultant Phase) stop-in at Marore. They will stop in at Marore. *mapia ikite' tawe' moting su Taruna.* good we (topic-actor) not (*mě'* Purposive Phase)[6] stop-in at Taruna. It would be better if we did not stop at Taruna.

In the Process Genius the action is linear, less concentrated, and broader as to conditions of fulfillment. Examples: *ia' diělo mangotong si Tiring su Turang.* I (topic-actor) tomorrow (*mang* Resultant Phase) stop-in for Tiring at Turang. Tomorrow I'll stop for Tiring at Turang. *motorě' pulisi měngotong sini kuade pia' sope'.* motor-boat police (topic-actor *měng* Purposive Phase) stop-in to-here relate have sail-boat. The motor boat of the police will stop here for it is said there are sail boats here.

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[6] When *mě'*- is prefixed to a vowel-initial base all but the *m*- is dropped.

A feature of Time is also present in nuclear predications. Time is the completeness of an action with respect to a certain reference point in time, and occurs irrespective of past, present, and future. Time may be Incomplete: *mapia ikite' tawe' motong su Taruna.* good we (topic-actor) not (*mĕ'* Incomplete Time, Purposive Phase, State Genius) stop-in at Taruna. It would be better if we did not stop at Taruna. Time may also be Complete: *isire kahĕbi notong su Taruna.* they (topic-actor) yesterday (*nĕ'* Complete Time, Purposive Phase, State Genius) top-in at Taruna. They stopped at Taruna yesterday.

SUBJECTIVE NUCLEAR PREDICATION

The distinguishing features of the Subjective Nuclear Predication are: (*1*) the affixes; (*2*) the topic of the construction, which in this case is the actor, or subject; and (*3*) the position of this topic in the sentence. The subject, as topic, stands in close syntactic relationship to the action, and it, together with the verb, controls the remainder of the sentence. This predication may also form a complete minimal sentence. The subject occurs most frequently in sentence-initial position, but may also occur sentence-final. These are the positions of greatest emphasis in Sangir sentences. The subject may occur as a noun (that is, a substantive), or as pronoun. When the latter it is of the *ia'* set, and it always occurs preceding the verb.

As previously discussed, a Nuclear Predication affix in Sangir reveals not only the syntactic, or clause-level relationship, but also the morphological or word-level relationship. An example of this combination of two levels is the affix *mang-*. In its entirety it distinguishes the nuclear predication as Subjective; its component parts reveal the lexical affixes of Incomplete Time (*m-*), Resultant Phase (*-a-*), and Process Genius (*-ng*). In the following illustrative section the affixes of the Subjective Nuclear Predication are listed with respect to their individual function.

Examples:

2.11 *ma-* (Incomplete Time:*m-*; Resultant Phase:*-a*; State Genius:-ϕ[7])

ia' maiang sini we. I (topic-actor) (*ma*) sit here emphasis. I'll sit here.

pakapia ĕndai pia' piso' sikau ĕntĕhang, ikau marlese. (*paka*) good there have knife to-you later you (topic-actor) (*ma*) wound yourself. Be careful there with that knife or you'll cut yourself.

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[7] ϕ indicates a zero morpheme.

ikami kimire tamakoa' sarang Gaĕng. we (topic-actor) (*-im-*) agree not (*ma*) make towards Glan. We agreed not to go to Glan.

2.12 *na-* (complete Time: *n-*; Resultant Phase: *-a-*; State Genius:-*ϕ*-)

ia' basa nĕ'tiki, nasĕse'. I (topic-actor) night (*nĕ'*) sleep (*na*) crowded. When I slept at night I was crowded.

laide narlese karluwaing napĕdi. leg-his (topic-actor) (*na*) cut back (topic-actor) (*na*) break. His leg was wounded, his back was broken.

su iuni mapurlo ia' nakoa' sarang Gaĕng. on June 10 I (topic-actor) (*na*) make towards Glan. On the 10th of June I went to Glan.

2.13 *mang-* (Incomplete Time:*m-*; Resultant Phase:*-a-*; Process Genius: *-ng-*) *ia' diĕlo mangunsa' mangotong si Tiring su Turang.* I (topic-actor) tomorrow (*mang*) wash-clothes (*mang*) stop-in for Tiring at Turang. When I wash clothes tomorrow I'll stop for Tiring at Turang.

ma'eng marĕndung taumata manuahĕ'. if dark people (topic-actor) (*mang*) shine-light. When its dark people shine a light.

i Ohi mangundang u undang u Indonesia. personal-indicator Ohi (topic-actor) (*mang*) medicine of medicine of Indonesia. Ohi uses Indonesian medicine.

2.14 *nang-* (Complete Time:*n-*; Resultant Phase:*-a-*; Process Genius:*-ng-*)

ia' Kahĕbi nangunsa' nangotong si Tiring su Turung. I (topic-actor) yesterday (*nang*) wash-clothes (*nang*) stop-in for Tiring at Turang. Yesterday when I washed clothes I stopped for Tiring at Turang.

nasongo i kaka' Marting bo'u Miangasĕ' nangarla' sikami. (*na*) arrive personal-indicator older-brother Martin (topic-actor) from Miangas (*nang*) fetch to-us. Older brother Martin arrived from Miangas to fetch us.

i Ohi odang masaki' nangundang u undang u Indonesia. personal-indicator Ohi (topic-actor) still (*ma*) sick (*nang*) medicine of medicine of Indonesia. When Ohi was sick she used Indonesian medicine.

2.15 *mĕ'-* (Incomplete Time:*m-*; Purposive Phase: *-ĕ-*; State Genius:-'-)

mapia ikite' tawe' motong su Taruna. good we (topic-actor) not (*mĕ'*) stop-in at Taruna. It would be beter if we did not stop at Taruna.

ia' tamai mĕ'dea' kalu. I (topic-actor) proceed (*mĕ'*) look-for wood. I'm going to look for wood.

ia' mĕ'geli' u kina' si Mama'. I (topic-actor) (*mĕ'*) give of fish to Mother. I'll give the fish to Mother.

2.16 *ne'-* (Complete Time:*n-*; Purposive Phase:*-ĕ-*; State Genius:-'-)

kahĕbi Kolombian notong sini. yesterday Colombian (topic-actor) (*nĕ'*) stop-in here: Yesterday the Colombian stopped here.

Johanes timumpa nĕ'dea' kapitalaĕng. Johanes (topic-actor) (*-im-*) jump-down (*nĕ'*) look-for councillor. Johanes came ashore to look for the Councillor.

ikau nĕ'gĕli' laku' sia'. you (topic-actor (*nĕ'*) give dress to-me. You gave the dress to me.

2.17 *mĕng-* (Incomplete Time:*m-*; Purposive Phase:*-ĕ-*; Process Genius: *-ng-*) *ikami su januari mĕngatu' barle.* we (topic-actor) in January (*mĕng*) roof house. In January we will roof the house.

i Mr. Reyes mĕngundang si Ohi. personal-indicator Mr. Reyes (topic-actor) (*mĕng*) medicine to Ohi. Mr. Reyes is treating Ohi.

ia' mĕnarluka' mamiahĕ' masina tadea'u makakoa'. I (topic-actor) (*mĕng*) try (*mang*) start machine so-that (*maka*) make. I will try to start the machine so that I will be able to do it.

2.18 *nĕng-* (Complete Time:*n-;* Purposive Phase:*-ĕ-;* Process Genius: *-ng-*) *isire nakoa' sarang Kapintana nĕngarla' pineda,* they (topic-actor) (*na*) make towards Kapintana (*nĕng*) fetch cassava-bread. They went to Kapintana to fetch bread.

ikami kanini nĕnoma' su Balut. we (topic-actor) earlier (*nĕng*) net at Balut. Earlier we fished at Balut.

ia' seng bo'u nĕndeno. I (topic-actor) already from (*nĕng*) bathe. I have already bathed.

OBJECTIVE NUCLEAR PREDICATION

The Objective Nuclear Predication patterns similarly to the Subjective in that the two Phases (Resultant and Purposive), the two categories of Genius (State and Process), and two features of Time (Incomplete and Complete) all occur.

The distinguishing features of the Objective Nuclear Predication are (*1*) two sets of affixes; (*2*) the topic of the construction, which is the goal or object of the action, and (*3*) the position of this topic in the sentence. The object, as topic of the sentence, stands in close syntactic relationship to the verb agent complex.

The Objective Nuclear Predication may form a complete minimal sentence, or it may be expanded into a sentence with subordinate units. The object occurs most frequently in sentence-initial position, but may also occur sentence-final. The object may occur as a noun, or as a pronoun. When a pronoun, it is always of the *ia'* set. When the agent of an Objective Nuclear Predication is a pronoun, it is of the *-ku* set.

A similar affix sequence occurs in the Objective Nuclear Predication as in the Subjective. These will be indicated in the examples that follow.

Examples:

2.21 *mi* . . . ϕ (Incomplete Time:*m-*; Resultant *Phase*:*-i* . . .-ϕ-; State Genius:-ϕ) *ikau mĕnginung binu' kapia we miwakang.* you (*mĕng*) drink wine (*ka*) good emphasis you (understood-topic-object) (*mi*) drunk (ϕ). Be careful; if you drink wine you'll become drunk.

ma'eng ia' mirating u Lagao ia' mĕndingo' u habarĕ' sikau. if I (topic-object) (*mi*) arrive (ϕ) of Lagao I (*mĕng*) send of news to-you. When I arrive at Lagao I'll send you news.

ma'eng tĕmbo'ku mĕ'kĕti' ia' miwanting Konsul. if head-my (*mĕ'*) hard I (topic-object) (*mi*) punish(ϕ) Consul. If I'm stubborn I'll be punished by the Consul.

2.22 *ni...φ* (Complete Time:*n-;* Resultant Phase:-i...-*φ*-; State Genius: -*φ*) *isie niwurlusĕ' su sasi'.* he (topic-object) (*ni*)sink(*φ*) in the sea. He was drowned in the sea.

taku' niwatang bowong. I (*ni*)topped-over(*φ*) water-tube (topic-object). I tipped over the water-tube.

ia' niwanting konsul tĕmbo'ku mĕ'kĕti'. I (topic-object) (*ni*)punish (*φ*) Consul head-my (*mĕ'*)hard. I was punished by the Consul for my stubborness.

2.23 *φ...ang* (Incomplete Time:*φ*-; Resultant Phase:*φ...a-; Process* Genius:*-ng*) *ikau taku' susukang*[8] *u penesileng.* you (topic-object) I (*φ*) inject(*ang*) of penicillin. I'll inject you with penicillin.

kawa ma'eng pilikang ru'rĕte. wire (topic-object) if (*φ*) cut (*ang*) (*ru'*) noise. Wire when cut makes a noise.

laku' ene bĕliang u satu pera. dress (topic-object) that (*φ*) buy (*ang*) of one peso. That dress will be bought for one peso.

2.24 *ni . . . ang* (Complete Time: *n*-; Resultant Phase:-*i . . . a*-; Process Genius: -*ng*)

nisusukang u pencsileng ia' sarang napia. ((*ni*) inject (*ang*) of penicillin I (topic-object) towards well. I was injected with penicillin until well.

kawa nipilikang u peda ru'rĕte. wire (topic-object) (*ni*) cut (*ang*) of knife (*ru'*) noise. Wire when cut with a knife makes a noise.

laku'ku taku' niwĕliang u satu pera. dress (topic-object) my I (*ni*) buy (*ang*) of one peso. The dress was bought by me for one peso.

2.26 *ni...φ* (Complete Time: *n-;* Purposive Phase: -*i...φ-;* State Genius: -*φ*) *i Lepi irolohĕ' sarang Lakirĕ' pĕmeli undang.* Personal-indicator Lepi (topic-object) (*i*) send (*φ*) toward Lakir (*pĕng*) buy medicine. Lepi is sent to Lakir to buy medicine.

kambing iarling su pia' kaĕnge, goat (topic-object) (*i*) transfer (*φ*) to have food-his. The goat is moved to where he will have food.

pakanandu mĕmĕlo' tarling barlango ĕntĕhang irandase. (*paka*) long (*mĕng*) put rope-of anchor (topic-object) later (*i*) drag (*φ*). Pay out a length of rope or later the anchor will drag.

2.26 *ni...φ* (Complete Time: *n-;* Purposive Phase: -*i...φ-;* State Genius: -*φ*) *i Lepi nirolohĕ' sarang Lakirĕ' pĕmĕli undang* personal-indicator Lepi (topic-object) (*ni*) send (*φ*) towards Lakir (*peng*) buy medicine. Lapi was sent to Lakir to buy medicine.

kambing niarling su pia' kaĕnge. goat (topic-object) (*ni*) transfer (*φ*) to have food-his. The goat was moved to where he could get food.

su Ladiangasĕ' lua' gaghuwa' barlangong kami nirandase. at Dadiangas waves (*ga*) big anchor-of (topic-object) our (*ni*) drag (*φ*). At Dadiangas the waves were very big; our anchor dragged.

2.27 *φ...ĕng* (Incomplete Time: *φ*-; Purposive Phase: -*φ...ĕ*-; Process Genius:-*ng*)

limu taku' pĕhaĕng su kina'. lemon (topic-object) I (*φ*) squeeze (*ĕng*) on fish. I squeezed the lemon on the fish.

ma'eng basa ia' kikiĕng u tĕni'. if not I (topic-object) (*φ*) bite (*ĕng*) of mosquitos. At night I am bitten of mosquitos.

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[8] The final glottal is replaced by *k* when *-ang* is suffixed.

laku' ene bĕliĕngku. dress (topic-object) that (φ) buy (*ĕng*) I. That dress will be bought by me.

2.28 *ni...ĕng* (Complete Time: n-; Purposive Phase: *-i...ĕ-*; Process Genius:*-ng*)

kina' taku' nipĕhaĕng u limu. fish (topic-object I (*ni*) squeeze (*ĕng*) of lemon. I squeezed lemon on the fish.

ia' niparentaĕng sarang Kalagan. I (topic-object) (*ni*) command (*ĕng*) towards Kalagan. I was commanded to go to Kalagan.

seng bo'u nipandaĕng ku, kai kodang tadie. already from (*ni*) look-at (*ĕng*) emphasis yet not-there-it. I did look for it but its not there yet.

BOOK REVIEWS

Books reviewed in this section represent a selection from those received from time to time by the National Institute of Science and Technology and the Philippine Atomic Energy Commission, two sister agencies under the National Science Development Board.

Disease, Life and Man: Selected Essays by Rudolf Virchow. Translated and with an introduction by Lelland J. Rather. Stanford, California, Standford University Press, 1958. viii + (2) + 273 p. Price, $5.00.

In this book, Lelland J. Rather has translated ten selected essays of Rudolf Virchow, a prominent German scientist who attained eminence in politics, archeology, social medicine, and anthropology during the later half of the nineteenth century. The book opens with an introduction in which the translator discusses the ideas of three investigators, William Harvey (1578–1657), Claude Bernard (1813–1878), and Rudolf Virchow (1821–1902) on the methodology of science. He reviews their works and provides an assessment of their contributions to scientific thought.

Virchow's esssays discuss such subjects as the split between "scientific" and "practical" medicine; the relation of medicine to history, philosophy, and religion; the significance of medicine as anthropological and social science; human understanding and the central nervous system; the pathology of the cells as the basis of the medical viewpoint; the human being as a unified commonwealth of cells; the distinction between the cause and the nature of the disease; and changes in the conception of life from Paracelsus to Hunter.

Of interest to readers would be Virchow's theory of the nature of disease and his insistence on the necessity of applying the scientific method to the study of life and man, both of which reflected and contributed to a habit of thought beginning to obtain dominance in his own time. He reduced disease to what he considered its core of actuality; and it appeared to him a physical, chemical, or anatomical disturbance of the fundamental unit of life—the cell. His conception of scientific method is very close to that of the present day.

The books is intended for the educated public since it is part of the author's credo that medicine should be a cultural force in the life of every individual, a form of *paideia*, as it was among the ancient Greeks.—P. T.

Cardiovascular Responses to Submersion Asphyxia in Avian Divers. By Einar Eliassen. Bergen—Oslo, Norway, Norwegian Universities Press, 1960. 100 p. 18 × 24.5 cm.

This is a study of the cardiovascular responses to submersion in avian divers both with respect to blood pressure and to peripheral circulation. The experiments were conducted partly in a field laboratory at Runde, near Aalesund, on the west coast of Norway, and partly at the Zoological Laboratory, University of Bergen.

The different sections of the paper are systematically arranged and presented although an added advantage would have been acquired had the graphs showing the cardiovascular pressures been included in the section on results and discussion. The section on methods is particularly well presented, covering all the pertinent details necessary for a thorough and clear understanding of the experimental procedures employed. Brief subtitles for the illustrative photographs are definitely called for in the appendix in order that reading may better be facilitated.

The paper has several typographical errors, in spelling especially, errors which could have been avoided by more careful proofreading.

Notwithstanding its minor imperfections, the paper as a whole makes for an interesting and substantial reading by researchers, especially physiologists.—R.R.

Fundamentals of Electronics. By F. H. Mitchell. Reading, Mass., Addison-Wesley Publ. Co., Inc., 1959. xii, 260 p. Price, $6.50.

This is the second edition of the book which is an introductory course in electronics, college level. The teachability of the book has been improved following the rapid developments in the field of electronics, and the illustrations of electronic components have been updated.

The first two chapters of a total of thirteen are dedicated to the principles of direct and alternating currents. A section on solving problems by means of complex numbers has been added to the second chapter. The major portion of the book deals with the fundamentals of electronic circuits, and with developments, functions and applications of electron tubes—vacuum diodes, voltage amplifiers, grounded-grid amplifiers, interstage coupling, maximum transfer theorem, sine wave oscillators, feedback oscillators, etc. The last three chapters deal with special-purpose tubes and devices, wave-shaping, control circuits, the electronic voltmeter, cathode ray oscilloscope and instrumentation. Every chapter is followed with problems, the solution of which helps greatly in understanding the subject matter.

While the author makes no pretense at completeness, the details treated are those that, as a whole, will give the student of electronics a thorough fundamental and practical graps of the subject matter.—E.P.R.

Physics of the Atom. By M. Russell Wehr and James A. Richards, Jr. Reading, Mass., Addison-Wesley Publ. Co., Inc., 1960. xii, 420 p. Price $6.50.

This introductory book to modern physics gives a clear insight of the developments from classical physics to the present frontiers of physical investigation. Intended for a one-term course in either a liberal arts or an engineering curriculum, the book is good for those who desire to keep abreast with modern physics.

The first six chapters deal with the atomic views of matter, electricity, and radiation; atomic models of Rutherford and Bohr; relativity; and x-rays. The last six chapters deal with waves and corpuscles, atomic view of solids, natural radioactivity, nuclear reactions and artificial radioactivity, nuclear energy, and cosmic rays and the fundamental particles. A chronology of the atomic view of nature, a list of Nobel prize winners, a periodic table of the elements, the properties of atoms in bulk, the MKS system, and atomic constants are among the eight items to be found in the appendices. Every chapter ends with problems and references calculated to help the student obtain a good grasp of the subject matter.

The book will appeal to the student because of its informal style and illuminating analogies. The mathematical treatment is clearly explained and the diagrams help greatly in understanding the important concepts involved in the modern study of the atom.—E.P.R.

Leeches (Hirudinea); Their Structure, Physiology, Ecology and Embryology. By K. H. Mann. London and New York. Pergamon Press, 1962. x, 201 p.

A very much neglected group of animals, the leeches have found a rather extensive treatment in this book, which, in fact, is the only book in English entirely devoted to them.

Of the ten easily read and profusely illustrated chapters, the first three serve as introduction for beginners. This part describes fully the medicinal leech, *Hirudo medicinalis,* as a type species giving its occurrence and external characters; its digestive, reproductive, excretory, nervous and blood systems; and its histology. It also gives a survey of the *Hirudinea* group naming and describing its various suborders and families. The succeeding chapters describe their nutrition, excretion, circulation, respiration, locomotion, sense organs, reproduction, development and ecology.

The author has made the book much more interesting and useful to both advanced students and senior zoologists by supplying appendices on the systematics of fresh water, terrestrial and marine leeches and an extensive bibliography on the subject.—A.B.A.

Elementary Theory of Numbers. By William J. LeVeque. Reading, Mass., Addison-Wesley Publ. Co., Inc., 1962. 132 p. Price, $3.75.

The number theory is as old as history and has been a subject of much interest to great mathematicians of the past and of the present. Although its application to the physical sciences has been very limited, the theory can arouse one's curiosity to know more about the interesting properties of whole numbers.

The text "Elementary Theory of Numbers" awakens such curiosity. It offers a challenge to the mind for deeper thinking and stimulation. It contains sufficient basic materials tending to organize and prepare the mind to better understanding and appreciate the subject.

Undoubtedly, the book is intended for undergraduate student. —E.B.A.

Safe Handling of Radioactive Isotopes in Medical Practice. By Edith H. Quimby. New York, The Macmillan Co., c1960. xii, 120 p. illus., tables. Price, $4.50.

This little book contains a compendium of basic information in the nature of radioactivity, diagnostic and therapeutic uses of radioactive isotopes, patient care instructions following administration of isotopes, precautions in the hospital and the "hot" laboratory, radiation hazards, procedures for dealing with radioactive contamination, radioactive waste, methods for determining exposure rates and maintaining low dose rates in the laboratory and hospital and problems of the surgeon, autopsy pathologists and the funeral director in cases of surgery or death of radioactive patients.

The author, Dr. Edith Quimby, an outstanding professor of radiology at the College of Physicians and Surgeons, Columbia University, has helped in the preparation of several U.S. National Bureau of Standards handbooks on radiation safety. She is at the same time an active member of leading radiology and physics societies of the U.S. and South America and has been the recipient of several medals from these societies.

In this convenient volume, Dr. Quimby gives students, technicians, doctors, nurses and anyone else involved in the use of radioactive isotopes in hospitals or medical practice, a valuable reference guide. More important it stresses the fact that while the dangers of radiation cannot be denied and should not ignored, neither should they be exaggerated.—A. P. C.

Modern Algebra and Trigonometry. By Eldridge P. Vance. Reading, Mass. and London, Addison-Wesley Publ. Co., Inc., 1962. 374 p. Price, $7.50.

In combining the basic ideas of algebra and trigonometry, the author places emphasis on definitions and discussions of hypotheses. As in most textbooks on both subjects, the student will find here careful organization and simple presentation of subject matter, plus ample exercises and sample solutions after each topic discussion.

In the early chapters the basic principles of trigonometry are introduced immediately after the discussion of graphical representation of algebraic functions. In succeeding chapters these are followed by a unified treatment of both subjects. This novel approach makes the book different from the ordinary algebra and trigonometry textbooks now used in our schools.

College students may find it difficult to start using the book. But, given serious study, it can be fascinating to them as the ideas on which the author has placed greater stress become easier to learn.—E.B.A.

Introductory Calculus. By Donald E. Richmond. Reading, Mass. and London, Addison-Wesley Publ. Co., Inc., 1959. xv pp. Price, $5.50.

This is a well organized introductory text in Calculus suitable for students with no knowledge of trigonometry and analytic geometry. It starts with functions and their graphs, and the concept of continuity and limits. The second chapter deals with derivatives and its applications. In the third chapter the idea of areas under a curve and the various applications of this idea have been clearly and concisely presented. Chapter 4 deals with the characteristics of exponential functions defined by 2^x and e^x. A novel treatment of analytic trigonometry with the use of complex numbers is contained in the concluding chapter.

Finally the author should be commended for attempting to attain a three-fold objective in the presentation of each chapter of the book; namely, (*1*) to develop only one central theme in each chapter; (*2*) to develop in the reader a firm understanding of the nature of mathematical thinking; and (*3*) to enable him to acquire as well some feeling for mathematical proofs.

This book will be useful for students of pharmacy, medicine and allied sciences where intensive knowledge of mathematics is not required.—C. G. B.

Progress in Industrial Gas Chromatography Vol. I (Proceedings of the Third Annual Gas Chromatography Institute at Canisius College in Buffalo, New York, April, 1961) edited by Herman A. Szymanski. Plenum Press, New York, 1961. 235 pp. Price, $8.50.

Twelve research papers covering various aspects of gas chromatography from the most recent developments in the field to the use of gas chromatography for analysis of odors, flavors and air pollution are presented. The first paper presents a brief history of the development of gas chromatography as an analytical tool.

Emphasis is on programmed temperature although there are discussions on column packing and size, effect of particle size and multiple column reversal on component resolution, and one paper on gas chromatograph detectors.

The book is a good reference book both for beginners and experts in the field. For beginners it contains some information on type of column and its typical application as well as operating temperature. Specialists in gas chromatography will be benefited by papers on specific problems and application and the panel discussion at the end of the book.

The bibliography contains 150 references.—J. A. A.

Calculus and Analytical Geometry. By George B. Thomas, Jr. Third ed. Reading, Mass. Addison-Wesley Publ. Co., Inc., 1960, 1010 pp.

Dr. George B. Thomas, Jr. indeed has shown his deep concern and interest to make Calculus and Analytic Geometry understandable and interesting to students of Science and Engineering. The organization of his book "Calculus and Analytic Geometry" is a reflection of his experience as a teacher in mathematics.

The style used in the presentation of the basic concept of differentiation and integration is simple enough that a student who has taken College Algebra, Trigonemetry and the Elements of Plane Analytic Geometry can surely pickup the fundamentals without difficulty and form a clear picture of the theory.

A brief review of particular fundamentals in Algebra and Trigonometry usually preceds a new topic for the benefit of the student.

A wide variety of exercises and problems are provided in every chapter to help the student apply his newly learned theories and principles. The more difficult topics are treated separately and presented with care to avoid confusion.

The book, however, is not only confined strictly to the study of the fundamentals and its application—additional topics had been introduced that are of value and useful to the student along his line of endeavor.

Most of the topics presented in the later chapters were so given to serve as an introduction to Advanced Calculus and Differential Equations.

To the teacher, the book is made to order. A straightforward, simple and effective pattern of instruction can be formulated by just following the order of the topics. It makes the teaching of the subject interesting so as to arouse the student's interest and organize his thoughts thus strengthen his foundation on the subject.

To the scientists and engineers, the book can be a very useful reference material because of its thoroughness and besides, the subject itself is rich and has been widely used as a tool in analytical work involving physical science and engineering.—E. B. A.

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PUBLICATIONS AVAILABLE

CONTENTS AND INDEX. THE PHILIPPINE JOURNAL OF SCIENCE, vol. 1 (1906) to vol. 10 (1915). Bureau of Science Publication No. 8 (1917). Paper, 442 pages. Price, $2.00, United States currency, postage extra.

SECOND TEN-YEAR INDEX. THE PHILIPPINE JOURNAL OF SCIENCE, vol. 11 (1916) to vol. 28 (1925). Compiled by Winifred I. Kelley. Bureau of Science Monograph 26. Paper, 382 pages. Price, $2.00, United States currency, postage extra.

CHECKLIST OF THE ANTS (HYMENOPTERA: FORMICIDÆ) OF ASIA. By J. W. Chapman and S. R. Capco. Institute of Science and Technology Monograph 1 (1951) new series. Paper, 327 pages. Price, $2.00, United States currency, postage extra.

NOTES ON PHILIPPINE MOSQUITOES, XVI. GENUS TRIPTEROIDES. By F. E. Baisas and Adela Ubaldo-Pagayon. Institute of Science and Technology Monograph 2 (1952) new series. Paper, 198 pages with 23 plates and 4 text figures. Price, $2.50, United States currency, postage extra.

A REVISION OF THE INDO-MALAYAN FRESH-WATER FISH GENUS RASBORA. By Martin R. Brittan. Institute of Science and Technology Monograph 3 (1953) new series. Paper, 224 pages with 3 plates and 52 text figures. Price, $2.50, United States currency, postage extra.

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AN ECOLOGICAL STUDY OF THE KOUPREY, NOVIBUS SAUVELI (URBAIN). By Charles H. Wharton. Institute of Science and Technology Monograph 5 (1957) new series. Paper, 111 pages with 11 plates and 16 text figures. Price, $1.25, United States currency, postage extra.

FERN FLORA OF THE PHILIPPINES. By Edwin B. Copeland. Institute of Science and Technology Monograph 6, Vols. 1–3 (1958–1960) new series. Vol. 1, 191 p., Paper, Price, $1.25; Vol. 2, 193–376 p., Paper, Price, $1.75; Vol. 3, 377–557 p., Paper, Price, $1.75, United States currency, postage extra.

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THE PHILIPPINE INDEX MEDICUS. Volume 3. By Aquilino Y. Argosino. National Institute of Science and Technology Special Publication (1961). Paper, 176 pages. Price, $1.50, United States currency, postage extra.

PACIFIC PLANT AREAS. Edited by C.G.G.J. Van Steenis. National Institute of Science and Technology Monograph 8, Vol. 1 (1963) new series. Paper, 246 pages with 26 maps. Price, $3.00, United States currency, postage extra.

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